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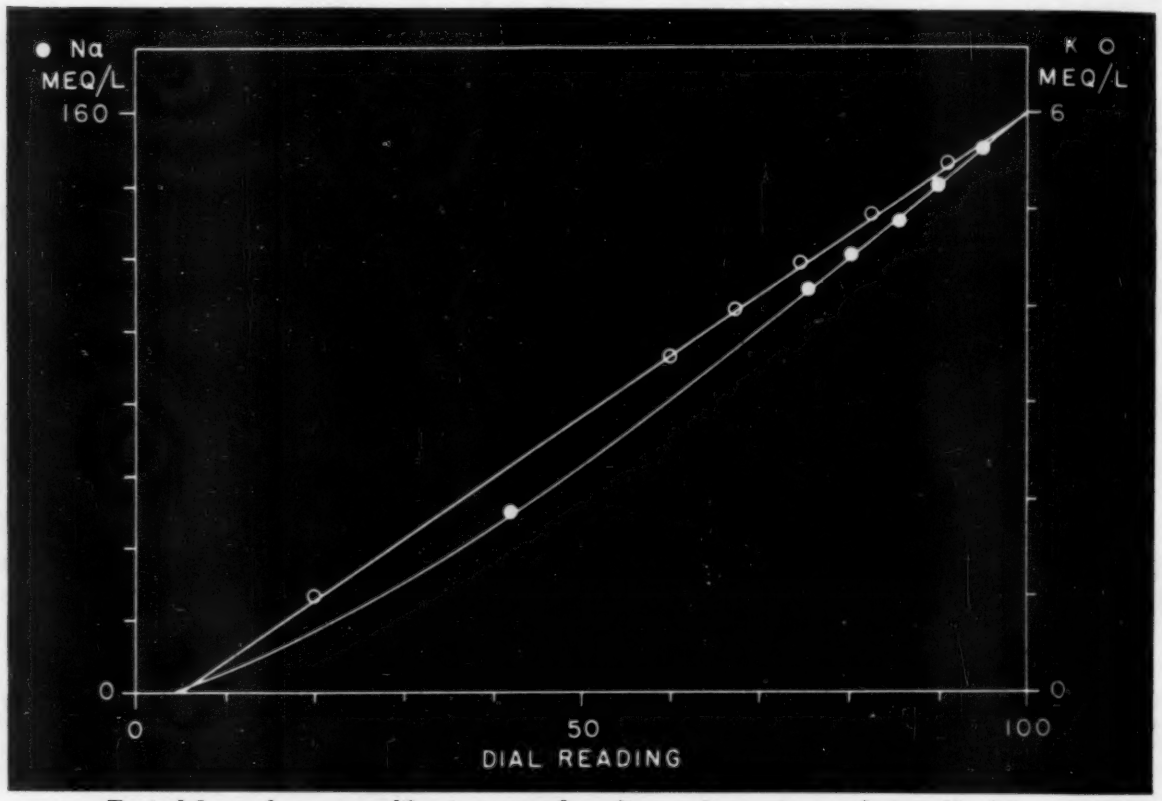


Typical flame photometer calibration curves for sodium and potassium analysis in blood sera. Na dilutions 1 to 100; K dilutions 1 to 20

Science and the Maintenance of Peace

Bart J. Bok

Harvard College Observatory

AT ITS MEETING IN PARIS (June 1948) the Committee on Science and Its Social Relations of the International Council of Scientific Unions voted to undertake an inquiry into some questions dealing with the subject of science and the maintenance of peace. It was decided to address the following two questions to a small but representative number of scientists who were known to have given considerable thought to the question of how scientists can contribute most effectively towards the maintenance of peace:

(1) In which measure do the methods of international scientific work contribute to the creation of an international spirit and to the maintenance of peace?

(2) In which ways could scientific organizations and scientists intensify their activities for the maintenance of peace?

At the request of the president of the CSSR, J. M. Burgers, of Delft, Holland, a number of these inquiries were distributed in the United States. The two questions were also discussed at the July meeting of the NRC Committee on UNESCO; several members of this committee have submitted answers. Since these questions are basic to the place of science in UNESCO, the NRC Committee requested the U. S. National Commission to devote time to discussion of these questions at the Panel Meeting on the Natural Sciences in Boston.

About 40 requests for replies and comments were distributed during the summer months. The present report represents an attempt to digest the opinions expressed in the 22 replies that have been received thus far. The names of those who contributed replies and their respective fields are as follows: I. Amdur (chemistry), I. S. Bowen (astrophysics), A. J. Carlson (physiology), R. Chambers (biology), R. E. Cleland (botany), K. T. Compton (physics), J. B. Conant (chemistry), R. W. Gerard (physiology), S. Goudsmit (physics), C. Kluckhohn (anthropology), S. Lefschetz (mathematics), W. T. Martin (mathematics), P. W. Merrill (astronomy), Melba Phillips (physics), W. O. Roberts (astronomy), H. N. Russell (astronomy), M. H. Stone (mathematics), O. Struve (astronomy), K. V. Thimann (biology), H. C. Urey (chemistry), M. B. Visscher (physiology), and D. Wolfle (psychology).

Interim report prepared by Dr. Bok as chairman of the National Research Council Committee on UNESCO, September 24, 1948.

The Sciences in UNESCO

In the words of the preamble to the constitution of UNESCO, the organization was created "for the purpose of advancing, through the educational and scientific and cultural relations of the peoples of the world, the objectives of international peace and of the common welfare of mankind for which the United Nations Organization was established and which its charter proclaims."

The principal task of UNESCO is to create an international atmosphere of peace. The organization is charged with the responsibilities of getting the peoples of the world to know each other better and of assisting those who are now underprivileged to better their lot. The sciences have a place in UNESCO, not only because they have a big contribution to make toward the achievement of a better material life, but also because scientists are potentially among the most effective ambassadors of good will. *Pierre Auger,* who heads the Natural Sciences Department of UNESCO in Paris, writes in the UNESCO *Courier* for August 1948: "Scientists have always formed a world brotherhood. Their problems, and the solutions they sometimes find, are truly human and therefore international. What wonderful scope for the development of collaboration and brotherhood between the different countries of the world! The only spadework needed for mutual understanding between scientists is the mere understanding of the same language: if they have this, two botanists or two physicists from the most distant continents are immediately drawn together by strong common interests."

Harlow Shapley expresses himself on this same subject in the concluding paragraph of his recent address on "The One World of Stars": "Supranationalism and cooperation across national boundaries are so simple and effective in the sciences that we have a clear responsibility to lead the way into an era of peace and human progress without which our efforts for human knowledge and human comforts will have been in vain" (*Science,* September 24, 1948).

A Digest of Answers to Question 1

Almost all correspondents stressed the basically international character of science. *Cleland* expresses

this as follows: "Science deals with universal phenomena. There is no such thing as an English Law of Gravitation or an Austrian Law of Inheritance. Since the phenomena and laws with which scientists deal are universal, it is natural for scientists of all nations to work together in the solution of common problems, to disseminate their discoveries widely, to develop machinery by which constant international contact is maintained. No group in the world is more in the habit of maintaining cordial international relations than the scientists. No group is characterized by a greater measure of understanding between nationals of different nations. Freedom from racial and national prejudice is the norm among scientists."

The following direct quotations from several of our correspondents show that many scientists feel strongly that, because of the special nature of their work, they are in a favored position with regard to international collaboration:

Bowen: International scientific work brings about many direct contacts between scientists of different nations on the basis of their science. This cannot help but increase the mutual understanding of each other's problems and lead to the elimination of causes of friction.

Conant: It seems to me quite clear that the international character of science is highly important both for the progress of science and as part of the general cultural interchange so important for the maintenance of our civilization.

Gerard: Science is international in all respects. Its content is known to all who are interested. Workers in all countries work together for common ends and build on one another's efforts. Scientists have, in a real sense, a common and precise language. Individuals in far places know and respect each other and even form firm friendships at a distance. Travel to and work in foreign laboratories is common among scientists and forges lasting ties and sympathy.

Goudsmit: The desire and the need of the scientists for world-wide cooperation should be an encouraging example to a world that is sorely in need of the cooperative spirit. It is only by breaking down the barriers of dogma, mistrust, fear and secrecy, only by the free exchange of ideas and the widest possible dissemination of truth, that science can continue to raise its level, and with it, the level of our civilization.

Kluckhohn: Over the long run it seems to me clear that the methods of international scientific work do contribute to the creation of an international spirit and to the maintenance of peace. It is very difficult to live as a scientist and to remain a nationalist in the narrow sense. As one looks at the whole stream of human history it is evident that wider loyalties have developed as a result of individuals from hitherto separate groups discovering that they were pursuing the same goals and that their own interest could best be served by working together.

Merrill: Science seems to be one of the very few areas in which international cooperation is at present both practicable and useful. Here the troublesome questions of integrity and mutual confidence are at a minimum. Successful cooperation in this relatively easy field might serve the interests of peace by tending to preserve or enlarge contacts between various nations, and by suggesting and stimulating cooperative experiments in more difficult areas.

Thimann: It may often happen that a scientist's closest contact, from the point of view of work, is a man in a distant country; in scientific interests he may have more in common with that man than with any of his colleagues in his own institution.

Struve: No one can possibly doubt that the methods of international scientific work contribute immensely to the creation of international solidarity among the peoples of the world and to the maintenance of peace. As an astronomer I am daily concerned with problems which not only transcend national boundaries but reach far out into space beyond the limits of the solar system and even our galaxy. I fervently believe that the ultimate aims of all mankind are the same and that the astronomers perhaps even more than other scientists must carry the message of world peace to those who have not the advantage of scientific thought.

Visscher: A real and natural basis for friendly association may be easier for scientists than for persons in most other occupations because science is naturally an international enterprise, its methods are universal, verbal factors are of minimal importance to it, and because factors of race, religion and nationality have nothing fundamental to do with progress in science.

Wolfle: The scientists themselves in their scientific work are probably as free from restrictions imposed by national boundaries as any group in the world. We read each other's reports (within the knowledge of our linguistic abilities), draw upon each other's results, combine findings, meet in international congresses and include representatives of other countries among our friends pretty much without regard to racial or national boundaries or differences. We might in a sense, therefore, serve as a model of international-mindedness as long as we are unfettered by nonscientific controls.

While most of our correspondents express the opinion that science and scientists have an important mission to fulfill in fostering international collaboration, some warn us not to expect too much, and one says

that the net result is zero. The following quotations are especially pertinent in this respect:

Carlson: Science is one and is consequently international. It could be rendered more international if scientists and science were identical. But, unfortunately, scientists are just human beings and do at times depart from the strict path of science, that is, do not always follow the proven facts with all the cards on the table face up. They do sometimes indulge in the common world practice of artistic lying.

Compton: It is quite a common experience for a scientist in one country to feel almost intimately acquainted with a scientist in his field in some other country, even though the two may never have met. So far as it goes, this is all to the good, and the more that it can be encouraged the better. *However,* I think it is clear that scientists form too small a proportion of the entire population to make this factor anything more than a relatively small influence, but it will generally be in a good direction.

Phillips: The internationalism intrinsic in scientific work does result in a community of feeling between scientists everywhere and is part of an "international spirit." But the extension of the methods of international scientific work to other aspects of international relations, while devoutly to be hoped for and worked toward, is not to be caught in a phrase or even in a solemn treatise. The ICSU is not going to be able to do very much about it, by itself.

Urey: I believe that merely scientific contact of scientists has comparatively little to do with securing peace. Peace is the by-product of responsible government, and not a by-product of a discussion of the origin of the carbon and nitrogen atoms in uric acid or the discussion of cosmic rays. UNESCO is important, as are all other international organizations, both scientific and otherwise, for without the community of interest which they establish responsible government cannot be established over the present divergent national groups of the world; but scientists will make a mistake if they think that their scientific activities are the direct way to accomplish this end.

In the listing of achievements, our correspondents stress those of the past quarter-century or so made by the present international scientific organizations, notably the unions, and they emphasize the importance of meetings. Almost without exception they point to the effectiveness of international exchanges of personnel at all levels. They comment favorably on international exchanges of scientific literature and on the advances made in scientific abstracting. The importance is stressed of several projects undertaken by the Natural Sciences Department of UNESCO, notably the establishment of the Field Science Cooperation Offices, the creation of the Hylean-Amazon Institute, the work on scientific reconstruction and that on the popularization and social implications of science.

Roberts expresses the opinion that the methods of science lead to world-wide cooperation and mutual understanding. He writes: "A basic factor in the method of science, for example, is the elimination of personal bias from the interpretation of events of the surrounding world. It is nearly impossible for scientists to avoid carrying over this impersonal approach when they assess politics or other social endeavor. Thus the method of science provides a way for men to put aside the conventional signal reactions, prejudices, and many of the other blocks to understanding things that are unfamiliar.

"Another factor in the method of science is the appreciation that must come to all scientists—that the development of theories is always an evolutionary thing and never static for long. This helps men to understand that their social theories, like all theories, are in the process of gradual change—that no sole theory or complex of theories is sufficient for all times or all places and that all systems will evolve in one direction or another at one rate or another—thus the method helps provide the flexibility of mind that is necessary if we are to maintain peace in a world inhabited by proponents of diverse and sometimes conflicting social schemes.

"Just to mention briefly one other essential feature of the method of science, I believe that the principle of freedom of inquiry which all good scientists must possess is a great asset in the maintenance of world peace. It is engrained in the spirit of scientists that in their progress there are no man-made absolutes, and that the ultimate principle by which all theories stand or fall is not authority, or force of will, but solely experiment—solely how well, how simply, and how usefully a given theory explains and predicts the various phenomena of the universe. This fundamental freedom is hard to reconcile with doctrinaire politics and impossible to reconcile with dogmatic adherence to particular theories of social or physical organization imposed by the dictation of a leader."

A Digest of Replies Received to Question 2

Natural Resources and Overpopulation. Several correspondents express extreme concern over the problems of overpopulation and lack of natural resources as they bear upon the maintenance of world peace. *Stone* writes: "It is only through the applications of science on an international basis in agriculture, industry, public health and population control that a balance between our limited world resources and our consumption can be achieved at a relatively high

standard of living and one of the most dangerous causes of aggression and war eliminated." *Lefschetz* expresses the opinion that the explosive growth of population everywhere is the principal long range cause for war. A clash between the United States and the Soviet Union (mainly due to lack of understanding between the two sides) is, according to *Lefschetz,* the most important cause for war in the immediate future.

Carlson writes: "The known factors that lead to war are overpopulation, undernutrition, uncontrolled greed, and antediluvian religions and philosophies. We know now on the basis of science that the present human race is one species and that there are saner and better ways of meeting human food needs and controlling excess human reproduction than the methods of war."

Two sample quotations may suffice to show the importance which scientists attach to the world's natural resources.

Amdur: To focus the attention on the use of science for conserving and developing the world's resources is one of the most effective ways for scientists and scientific organizations to contribute to the maintenance of peace. No single cause for wars can definitely be said to be the most important one, but I am sure that if the world's resources could be developed to take care of economic needs of peoples to a greater extent than in the past, those causes of war which are tied up with economic rivalries would be much less important.

Cleland: Most modern wars have been brought about as the result of economic pressures, based on the Malthusian principle. Only science can remove the basis of these pressures. Scientific control of population, the production of more efficient crop plants and domestic animals, the proper exploitation of vast areas of potentially usable land, control of soil erosion, development of irrigation and other projects designed to increase arable land, the discovery of new sources of energy—these are activities which will remove the chief cause of war. Without such activities, no amount of talk or education will achieve lasting peace.

UNESCO's activities in connection with the forthcoming United Nations Scientific Conference on the Conservation and Utilization of Resources are wholly in line with the above suggestions, as are the attempts to assist in the formation of an international union for the protection of nature.

International Unions and Congresses. The majority of our correspondents, notably Bowen, Cleland, Conant, Compton, Martin, Phillips, Roberts, Russell, Struve, Thimann, Visscher, and Wolfle, attach a great importance for the future to continued support of the work of the international scientific unions, and they urge holding frequent international scientific congresses.

Cooperative Research. A number of correspondents point to the importance of cooperative research projects with scientists as individuals, or institutions, from two or more nations collaborating. The following sample quotation shows that scientists would welcome the establishment of international laboratories and observatories under United Nations auspices:

Merrill: International laboratories might be established for intensive research on the great health problems of mankind, for example, cancer, arthritic diseases, the common cold. A large cooperative astronomical observatory in the Southern Hemisphere might be considered. Possibly an improved world calendar could be advocated.

Exchanges, Fellowships and Scientific Missions. *Martin* lists as one of the most important activities the "wide exchange of scientists and scientific students on a visiting basis with travel and passport regulations as simple and flexible as possible." This same thought is expressed clearly by *Cleland* who writes: "We must enlarge as much as possible existing programs for the exchange of students. Nothing can be more effective in bringing about mutual understanding than giving large numbers of students the opportunity to study in other lands and to become acquainted with other peoples at the time in life when they are still plastic and impressionable. The more students can experience a satisfying experience abroad, the more nearly will we approach the goal of mutual sympathy and understanding."

An interesting suggestion is made by *Thimann*: "Without doubt one important way in which the international spirit of science could be increased and given more impetus is by increasing the *personal* contacts among scientists of the world. The exchange of personnel that now goes on, while very useful, influences only a very small fraction of the men involved. We need a very much greater exchange of personnel in the form of visiting lectureships and travelling fellowships. These should not be mere tours of inspection but should involve actual residence for not less than a term or perhaps a year. They should involve not only university staff and students but men working for Government and industry. Travelling fellowships for industrial scientists would be particularly useful.

"Towards the close of the 19th century it became very common for biologists and chemists of England and America to go to Germany for graduate work and to take their doctorates there. Arrangements of this kind involving a *really* large fraction of the total sci-

entific men are needed. Practically every scientist should, by age 30, have spent at least a year studying abroad."

Gerard and *Visscher,* who have both participated in the medical mission organized by the Unitarian Service Committee, stress the importance of international scientific missions organized with the specific aim of aiding and assisting the scientists and the population of the region. *Roberts* points to the need of simplifying the movement of scientists across national boundaries. He writes: "Every effort should be made to simplify the passport and visa requirements to give scientists freer access to all countries. If the many-times-proposed plan for the issuance of UNESCO passports' could be worked out so that people carrying these passports could have free access to all UNESCO countries, it would be a great step in the right direction."

On the same subject *Stone* writes: "Scientists and their organizations can contribute to the maintenance of peace by working to break down artificial barriers to communications, travel, and cooperative endeavor which seriously obstruct the development of world science in all its aspects, including its application to some of mankind's most pressing problems."

Popularization and Social Implications of Science. The principal recommendation made by *Carlson* is the following: "More factual scientific education and understanding of the populations in all lands would greatly diminish the drives or needs for war. In my judgment and experience, this phase of education on an international scale is primarily a social responsibility of the scientists."

Amdur expresses the opinion that continued popular education in the field of atomic energy is needed. *Gerard* feels that a big opportunity is being lost since we are not stressing to a greater extent the popularization of the use of the scientific method and since we are not attempting to introduce this attitude early in the formal education of our children.

Gerard and Visscher urge the fullest support of the social sciences. We quote them as follows:

Visscher: The scientific method can and must be applied to the greatest problems of human life, the problems raised by peoples having to live with one another on a single planet made small by the advances in the physical sciences. All prior attempts to create conditions conducive to peace have failed. Man must be allowed to use the constructive power of the scientific method in this sphere. This method is not a tool of infinite utility, but, until its usefulness in this area has been exhaustively tested, no one has grounds for rejecting it. The survival of the human race as a whole is in jeopardy today.

Gerard: The social sciences are still feeble and groping, and mental ones hardly less so, and many maintain that human problems must remain extra-scientific. Most scientists are convinced otherwise; and this position at least has the merit of inviting rather than dissuading effort. Other modes of thought and feeling have been tried and have failed to achieve harmony among men. The mode of science—rational extrapolation from reliable knowledge, subjected to operational test—may also fail, but it surely deserves its trial. This is, indeed, also the avowed mode of democratic government and is being approached, however slowly, in actuality.

Publications and Abstracting Services. General approval is expressed of UNESCO's activities in the field of abstracting and international scientific publications. *Chambers* expresses the belief that "an international spirit in scientific work would be greatly aided by the establishment of more active international polyglot (English-French-German-Italian) scientific journals." *Struve* makes the following suggestion: "It would be important to stimulate a more active exchange of scientific publications and develop a system whereby scientific articles by American workers may be published abroad while papers by foreign authors may appear in American journals. Difficulties of exchange now make it impossible for European institutions to pay the cost of publication in America, but an exchange of publications might well remove this difficulty."

The Twilight Areas of Culture. Cleland writes: "Scientists in the more advanced countries should do everything possible to encourage science in the less favored areas, by training increasing numbers of foreign students, by consenting to serve as visiting professors or as members of commissions sent to other countries to encourage and assist in developing their scientific programs, by acting as consultants in the solution of nutritional, medical or other problems confronting the scientists of other countries, by taking an active interest in the international scientific unions, by lending support to all international scientific agencies, by contribution toward the rehabilitation of devastated laboratories and libraries, and any other way possible."

Stone: Scientists and their organizations can continually and vigorously urge the need for so organizing education in all countries that a sufficient number of adequately trained scientists will be available to each national group in its attempt to share in the benefits conferred by science.

Phillips urges that special attention should be given to the encouragement of scientific growth in backward countries. She points further to the continued need for activities in the field of rehabilitation of science

in war-devastated countries. It appears that the majority of our correspondents is agreed that UNESCO's Field Science Cooperation Offices fill a distinct need and that UNESCO has done very useful work through its program of scientific rehabilitation.

Concluding Observations

Scientists and Citizens. Compton writes: "I happen to be one who feels that the responsibilities of scientists are just like the responsibilities of any other group of citizens when it comes to the matter of responsibility for peace. I do not believe that it is feasible or, in the long run, safe for scientists to attempt to exert their own controls on the products of their work. They are but one of the contributors to our intellectual and economic strength and it is the impact of the population as a whole that has the predominating control, in my judgment."

Russell agrees with this view and writes as follows: "The problem of maintaining peace is so deeply entangled with many sincere differences of social and political belief that, in my judgment, it would be unwise for scientific organizations, as such, to endorse any particular programs. It is better for individual scientists to act as citizens, in cooperation with others who hold similar convictions."

In a letter bearing on the subject *Bowen* writes: "Projects should be planned primarily from the standpoint of the advancement of science involved in the most effective manner. If the scientific standpoint is made secondary to deliberate peace propaganda, the whole program will become political in nature and very little will be accomplished either in the advancement of science or of peace."

A remark by *Roberts* deserves to be quoted at this point: "I feel that it is actually far more important for them to join their efforts in a genuinely important scientific problem than it is for them to try to bridge the political chasms that exist by any direct action."

The Iron Curtain. Most correspondents refer in one way or another to the urgent need of lifting the "iron curtain," which separates the East from the West. The astronomers quote several instances in which the iron curtain has been pierced in recent years through sincere efforts from scientists on both sides. But the curtain admittedly becomes more real every day. Some are quite pessimistic. *Conant,* for example, writes: "It is hardly possible for the scientists as such to affect the practices of certain countries in which freedom of travel is highly restricted and which more and more appear to be using academic men as propagandists of special views of essentially a political nature. Perhaps patience and continued endeavors to promote international exchange along old-fashioned lines is all that we can hope for in these troubled times. I am a firm believer that better days will sometime dawn and as times improve, the chances of having international scientific meetings with their old spirit may also improve."

Others feel that the time for action is by no means over. The following two quotations take this point of view:

Struve: Unrelenting efforts should be made to remove from the field of science the present division of countries on two sides of the "iron curtain." In particular, efforts should be continued to bring about a more active participation in scientific organizations of the scientists of Russia and of countries in the Russian orbit. That such efforts can be successful has been strikingly demonstrated by the invitation recently confirmed to hold the 1951 International Astronomical Union in Leningrad.

Thimann: The second most important step forward will be taken when free exchange not only of men but even of publications and research results takes place with the Soviet Union. The present tendency of Soviet journals to omit presentation of summaries in English, French or German represents a serious loss of the international spirit. Free correspondence with Soviet scientists is also necessary. If it were possible to extend the exchange of personnel mentioned above to the Soviet Union, even in small part, this would be perhaps the most important activity which scientists could undertake for the maintenance of peace.

Kluckhohn fears that scientists will be able to influence only to a very slight degree the various governmental interferences with the freedom of movement across national boundaries and the freedom of expression. He writes, however: "It is all too true at the moment that certain individuals in certain countries label even the most detached of natural science enquiries in accord with competing ideologies. However, I cannot but feel that this is only a temporary phase which cannot endure. The deepest loyalty of the scientist is inevitably to the facts of nature which know no ideological boundaries."

Science Fosters Peace Rather Than War. Nonscientists frequently charge that modern science is basically destructive. Vigorous objections against this point of view are voiced by our correspondents.

Cleland: The impression that science fosters war rather than peace is based upon a misconception of the activity of scientists and of the breadth of the field of science. Many nonscientists have a myopic view of science, being impressed with the effectiveness of physics and chemistry in the late war and forgetting the many sciences whose fields contribute only to the arts of peace; forgetting also the fact that the major activities of physicists and chemists have always been devoted to the building of a richer civiliza-

tion. Their efforts have only incidentally been directed toward wartime objectives, and only unwillingly and under stress of emergency. No group is more conscious of the disastrous possibilities of war in the atomic age than the scientists themselves. No group has been as vocal as the nuclear physicists in condemning war and in supporting efforts to achieve world-wide cooperation.

In discussing the biological sciences *Gerard* writes: "The biological sciences, however, have also reached the stage of expanding application, and life expectancy is rising precipitously. The X-ray alone saved more lives than were lost in World War I, and who can doubt that antibiotics will far more generously cover the losses of World War II. Such facts are not dramatized and are little known. Indeed, science has, with the exception of a few devoted scientists, preferred an esoteric status and has insulated itself from its society. This must be radically altered."

Funds to Fight for Peace. *Roberts* adds new emphasis to a suggestion that has been made several times in the past. We reproduce his comments here without further remarks: "Another thing which has been discussed many times, and which to me appears to possess great merit, is the proposal that some specific percentage of all funds expended for purposes of national military defense be expended in specifically peacetime and humanitarian activities. The details of the administration of such a program have been discussed by a number of people, and I feel that several satisfactory and workable plans have been offered. One of the best of these, to my way of thinking, is the establishment of an actual cabinet post and entire government department for these functions and activities. The benefits and findings of this department should, I believe, be made freely available throughout the world, without regard to nationalism, without regard to politics or prejudices. Perhaps this is a bit visionary and utopian, but to me it seems immensely sound."

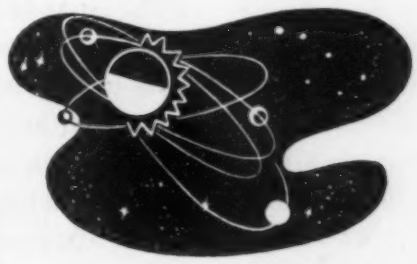
Ultimate Aims. Several correspondents allude to the ultimate aims toward which the work for world peace must lead. *Urey* sees this in the establishment of world government. He writes as follows: "In attacking a large scientific problem, we all go back to fundamental principles, and we face our problems fairly and squarely. If they involve very difficult things, we nevertheless recognize that our problems are difficult and do not try to solve major problems by following up side issues or the minor fringes. The problem of securing peace is the greatest that humanity has ever faced, and scientists will do their best in furthering this problem if they frankly recognize the fundamental problem, namely, world government, and speak those words firmly and fearlessly whenever the question is introduced. Without this there is no hope anyway."

Several correspondents point to the value of world-wide cooperation in science as an example for similar cooperation in other fields:

Goudsmit: Not until the world realizes that world-wide cooperation is necessary, not only for the progress of science but for the progress of all phases of civilization, can we hope for lasting peace. As science is only a small fraction of human endeavor, its influence is not large enough to promote this cooperation beyond its own boundaries. Scientific organizations can, however, make known to the world the benefits they derive from such cooperation.

Stone: International cooperation in science gives valuable experience and training in the conduct of activities directed to a high purpose above purely nationalistic considerations, and can point the way for similar enterprises undertaken to solve the common problems of nations.

Perhaps the attitude of science is summarized best in the following cautious words of *Wolfle*: "It is a matter of hope rather than one of history that the increasing knowledge of the world, improved communications and transportation of goods, and raised standards of living can minimize the causes of war by reducing needs of aggression. The hope is, however, one that is worth mentioning and worth establishing as a goal for our political thinking."



Sir D'Arcy Wentworth Thompson, C.B., F.R.S. (1860–1948)

Robert Chambers, *New York University*

SIR D'ARCY WENTWORTH THOMPSON, one of the greatest academic figures in biological science, was a true naturalist with a wide range of intellectual interests and attainments. A Greek scholar, he possessed a unique sense of the classics, which he brought into his interpretations of contemporary scientific thought.

Biologists of past generations mastered much of the knowledge of their times in all known fields of the natural sciences. With the passage of time each of these fields has been so greatly developed that specialization has been the inevitable result, and biologists, along with other scientists, have become largely specialists. Sir D'Arcy belonged to neither category, encyclopedist or specialist. His strength lay in his attention to broad, simple principles developed through extensive knowledge of ancient and modern philosophical thought. His was an integrated outlook, based on broad understanding of these principles and appreciation of mathematics with its precision, and nature with its greatly varied phenomena.

Thompson, born in Edinburgh, Scotland, May 2, 1860, was the grandson of a shipmaster of Maryport, Cumberland, England. His father, also D'Arcy Wentworth, was born at sea off the coast of Van Dieman's Land, attended Pembroke College, Cambridge, and became classical master at the Edinburgh Academy and afterwards professor of Greek at Queen's College, Dundee. The father was alive to social and educational problems of the day. His liberal ideas are expressed in his books, written in a whimsical and fascinating style: *Daydreams of a schoolmaster* (1864), and *Wayside thoughts: being a series of desultory essays on education* (1868). The latter covers the subject matter of his twelve Lowell Institute Lectures, delivered in Boston during the season of 1867–68. In these lectures he also paid tribute to the New World for having done so much for women's rights.

His mother, Fanny Gamgee, belonged to a family distinguished in science and in medicine. Privileged in having such a background, the son in addition showed an intense love of nature from his early boyhood throughout his life. His preliminary studies were at Edinburgh Academy, a school long famous for the brilliant scholars it turned out. At the age of 17 he matriculated as a medical student at the University of Edinburgh. There he came under the influence of Sir Wyville Thompson, who had lately returned from the Challenger Expedition. At the age of 19 D'Arcy Thompson published a couple of papers on hydroid taxonomy and on a Pleistocene fossil seal. After two years in Edinburgh he obtained a classical scholarship which took him to Trinity College, Cambridge. There his inclinations towards zoology were furthered by his contacts with F. M. Balfour and Michael Foster, who were then laying the foundations of the modern Cambridge School of Biology. For a year he served as demonstrator in Michael Foster's laboratory of physiology. While at Cambridge he translated H. Muller's work on the fertilization of flowers, which was published with an introduction by Darwin. Concerning this D'Arcy Thompson wrote: "Charles Darwin's preface, full of suggestion, full of kindly appreciative feeling, is of peculiar interest as one of the very last of his writings." In 1884, at the early age of 24, he was appointed professor of biology in the recently founded University College in Dundee. In 1897 the College was united with the University of St. Andrews and he became a member of the Senate. Later, he was appointed to the senior chair of natural history in the United College of St. Salvator and St. Leonard, St. Andrews, Scotland. His tenure of the chairs at Dundee and at St. Andrews had extended for 64 years when he died at the age of 88.

In 1896 and 1897 Sir D'Arcy went to the Bering Sea as a member of the British-American inquiry into the fur seal fishery, and represented Britain in the international conference on the subject at Washington. For these services he received the title of Companion of the Bath in 1898. He was one of the British representatives on the International Council for the Study of the Sea from its beginning in 1902, and he edited and contributed largely to the Scottish section of its reports. He also wrote many papers on fishery statistics and oceanography in the Scientific Investigations of the Scottish Fishery Board from 1913 to 1931.

In 1908 he published a short paper in *Nature* on "The Shapes of Eggs and the Causes which Determine Them." This was the first published intimation of a line of inquiry that had long engaged his thought and on which he had accumulated masses of notes.

His book *On growth and form* appeared in 1917. This immediately attracted attention both because of its novel approach and because of its mass of illustrative material gathered from ancient and modern writers. In his own words: "The road of physicomathematical or dynamical investigation in morphology has found few to follow it; but the pathway is old. The way of

the old Ionian physicians, of Anaxagoras, of Empedocles and his disciples in the days before Aristotle, lay just by that highway side. It was Galileo's and Borelli's way; and Harvey's way, when he discovered the circulation of the blood. It was little trodden for long afterwards, but once in a while Swammerdam and Reaumur passed thereby. And of later years Moseley and Meyer, Berthold, Errera and Roux have been among the little band of travelers. We need not wonder if the way be hard to follow, and if these wayfarers have yet gathered little. A harvest has been reaped by others, and the gleaning of the grapes is slow. . . . Morphology is not only a study of material things, but has its dynamical aspect, under which we deal with the interpretation, in terms of force, of the operations of Energy. And here it is well worth while to remark that, in dealing with the facts of embryology or the phenomena of inheritance, the common language of the books seems to deal too much with the *material* elements concerned, as the causes of development, of variation or of hereditary transmission. Matter as such produces nothing, changes nothing, does nothing; and however convenient it may afterwards be to abbreviate our nomenclature and our descriptions, we must most carefully realise in the outset that the spermatozoon, the nucleus, the chromosomes or the germ-plasma can never *act* as matter alone, but only as seats of energy and as centres of force."

The central theme of the book is an enquiry into how far the form and structure of living things can be interpreted in terms of physical forces acting within the lifetime of an organism. This method of approach of causal morphology is to be distinguished from the historical morphology which was the almost exclusive study of the preceding period.

At the insistence of many friends he published in 1942 his second much enlarged edition (1116 pp. Cambridge University Press and the Macmillan Company) in which he emphasizes "the twofold problem of accumulated inheritance and of perfect structural adaptation [which] confronts us and passes all understanding." Dorothy Wrinch, who knew D'Arcy Thompson well, says, in her review of the book in *Isis*:[1] "One experiences, page by page, the feelings of a guest at a banquet of learning and insight, of knowledge and feeling. Those who wish to add to our fundamental understanding of biological structures must arm themselves with weapons from other sciences, yet at the same time develop to its highest pitch a proper feeling for biological materials. As we feed ourselves at this table groaning with good things, we see that one biologist at least accomplishes this."

A striking testimony to the influence of this book is given in a volume of "Essays on Growth and Form presented to D'Arcy Wentworth Thompson" edited by W. E. LeGros Clark and P. B. Medawar, published by the Clarendon Press in 1945. In this volume is included his bibliography.

Sir D'Arcy's classic leanings are expressed in his studies on the natural history of the ancient world. His *Glossary of Greek birds* appeared in 1895 and a second edition in 1936; his translation of Aristotle's *Historia animalium* was published in 1910 and his *Glossary of Greek fishes* in 1945. One of his invaluable services was as a member of a staff for the revision of Liddell and Scott's Greek-English Lexicon (Clarendon Press).

Concerning his glossaries Sir D'Arcy states: "Many old bird names and fish names are recorded by Italian scholars from the rich dialects of Italy, and new light is thrown thereby on obscure Greek and Latin; but the dialects of Modern Greece are still all but unknown. Some day, scholars will explore, to our great advantage, the common speech and folk-lore of the bird-market of Athens and the fish-market of the Piraeus, and of all the islands and all the provinces of Greece.

"Many a Greek word or hero name was foreign to Aryan speech. The merchant and mariner had brought strange words home from overseas; and many a beast and bird and hill and river had kept its pre-Hellenic name, harking back it might be to the nameless and forgotten language which was spoken by the Gods."

A brilliant essay is his "Science and the Classics," delivered as his presidential address to the Classical Association, Cardiff, and published in *Nature*, May 25, 1929. Its allusions open up a wealth of beauty and appreciation by showing the significance of the terms used for objects of nature in their relations to stories in prose and poetry of the ancient writers.

His quest was not so much a thirst for knowledge as for the thrill of revealing beauty. The following is quoted from the last paragraph of his address: "Whether we be taught science or the classics in our boyhood is not the last word of all. But whichever of the twain it be, let us so learn it as to live it, and so love it that we may love it to the end. Science and the classics—both alike continually enlarge our curiosity, and multiply our inlets to happiness."

His writings and speeches are rich with literary allusions and their volume attests to his fertile mind and breadth of knowledge. John L. Myers once asked him concerning the Homeric description of the death struggle of Nestor's chariot horse which Jupiter caused to be struck through the forehead by the arrow of a thunderbolt. The reply was immediate: "The arrow had grazed the cerebellum and the convulsive

(*Continued on page 151.*)

[1] Dorothy Wrinch, *Isis*, 1942–43, **34**, 232. See also G. Evelyn Hutchinson, *American Scientist*, 1948, **36**, 577; Frederick S. Hammett, *J. Hered.*, 1943, **34**, 85.

The Path of Carbon in Photosynthesis IV: The Identity and Sequence of the Intermediates in Sucrose Synthesis[1]

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THE IDEAL DESIGN OF AN EXPERIMENT to determine the chemical path of carbon from carbon dioxide to the variety of plant constituents is relatively simple and straightforward. It would consist of feeding a photosynthesizing organism radioactive carbon dioxide for various lengths of time and stopping the reaction by killing the plant. By determining those compounds into which the radioactive carbon has been incorporated for each period of illumination and, further, by determining the distribution of radioactivity within each compound, these data could then be used to construct a family of curves depicting the increase in radioactivity in each compound (and in each carbon atom of each compound) as a function of time. From a complete set of such curves it should be possible to draw a map of the path of carbon as it flows into the plant in the form of carbon dioxide and distributes itself among all the plant constituents.

A few such experiments have already been reported (*1–4, 6*). The present paper reports some further experiments toward this end with specific reference to the synthesis of sucrose.

The data are in the form of radioautographs of paper chromatograms made from the extracts of algae which have been photosynthesizing for several different periods of time, as well as one showing the dark fixation after a preliminary period of illumination in the absence of carbon dioxide.

Exposure of algae to $C^{14}O_2$: One-day-old *Chlorella pyrenoidosa* cells were grown under continuous culture conditions (*3*) and harvested immediately before use. A suspension of 1 cc of packed cells in 70 ml of water containing fumarate buffer (3.5 mg fumaric acid plus .032 meq sodium hydroxide) was allowed to photosynthesize for 30 minutes with 4% carbon dioxide in air. This gas mixture was then displaced by rapid flushing with air during 5 minutes. A solution of 40 μc of $NaHC^{14}O_3$ (.0143 mmol) in 0.20 ml was rapidly injected into the suspension. The vessel was shaken vigorously in the light beams (2 × 17,000 lux) until the algae were killed by opening an 8-mm stopcock and allowing the solution to flow into a beaker containing 500 ml of boiling absolute ethanol. The alcohol suspension was filtered with celite and evaporated at room temperature to a volume of 2 cc for convenient application on the filter paper sheet.

Preparation of chromatograms: Fumarate buffer in distilled water was chosen for this work, since inorganic salts, especially phosphates, interfere with movement of compounds on the paper. Alcohol extract of as much as 100 mm^3 of algae may be applied to the filter paper (Whatman No. 1). Development in water-saturated phenol was followed by thorough drying at room temperature. The second solvent was freshly prepared before use from equal volumes of the following solutions:

(A) 1,246 cc *n*-butanol—84 cc water

(B) 620 cc propionic acid—790 cc water[2]

In order to choose a suitable exposure time for the X-ray film (Eastman No-Screen, 14″ × 17″) the activity of the original spot is determined on the paper. With the number of compounds appearing in a 90-second photosynthesis, an activity of 30,000 cpm is sufficient to expose the film in 48 hours.

Although the radioactive fixation products which have been separated in the chromatogram may be eluted and their activity determined accurately, the radiogram serves as a semiquantitative record of the activity fixed in each compound. The relative amounts of each active product may be compared visually in the radioautograph.[3]

An examination of the radiograms reveals that in the very short photosynthetic experiments (30 seconds and 90 seconds) by far the major portion of the newly reduced carbon dioxide is found in the phospho-

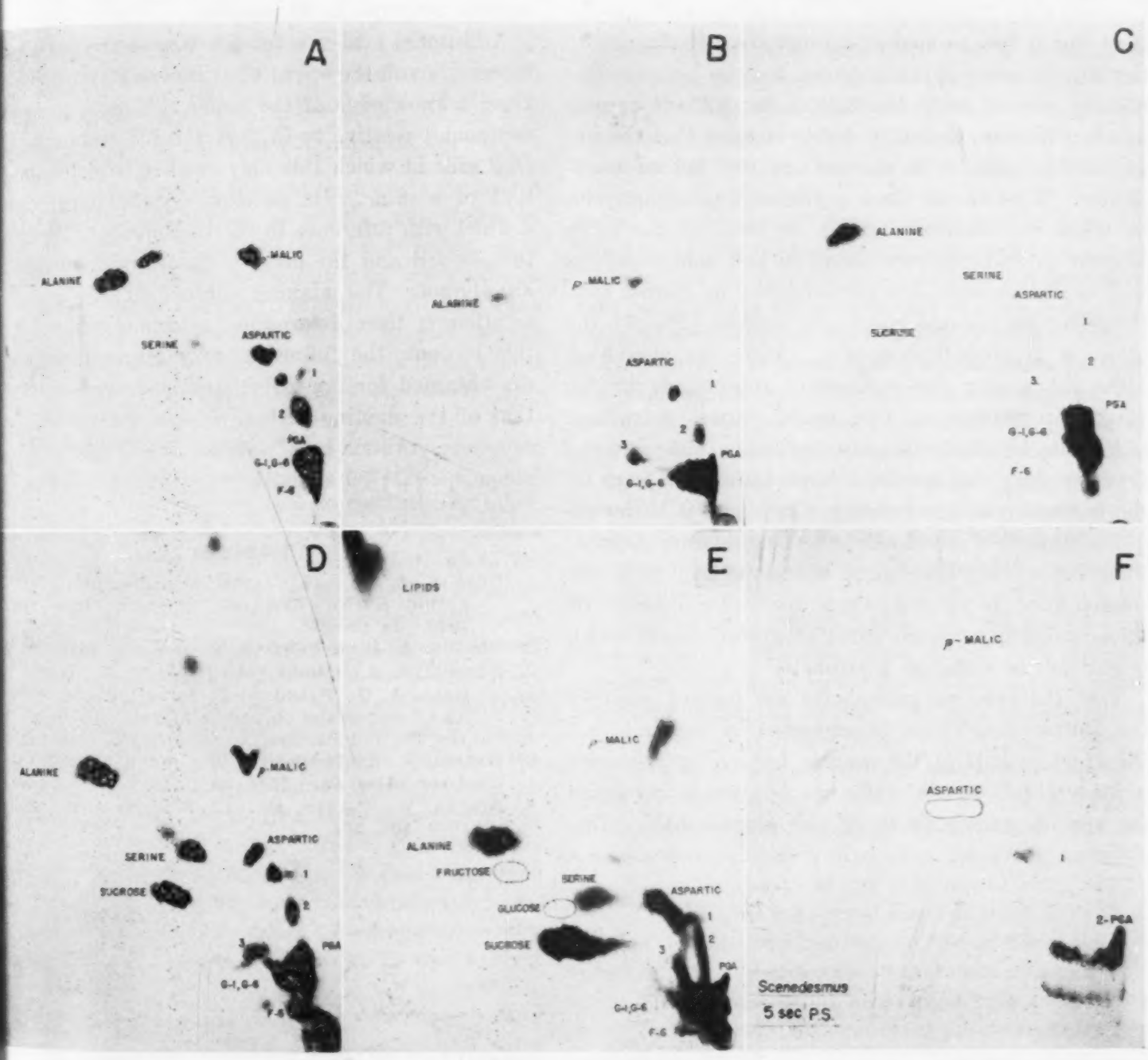
[1] This paper is based on work performed under Contract No. W-7405-Eng-48 with the Atomic Energy Commission in connection with the Radiation Laboratory, University of California, Berkeley.

[2] The solvent is adjusted to separate into two phases if cooled two degrees below the temperature at which it is used.

[3] The details of the methods of identification of the spots will be published elsewhere. ("The Path of Carbon in Photosynthesis. V. Paper Chromatography and Radioautography of the Products" by A. A. Benson, J. A. Bassham, M. Calvin, V. A. Haas, and W. Stepka.)

glyceric acids, triose phosphates and the hexose phosphates. This may be taken as additional confirmatory evidence of our previously proposed (*4*) scheme by which the six-carbon hexose skeleton is synthesized through the usual glycolytic intermediates. The details of the path by which the phosphoglyceric acid is formed and the relative rates of the several reactions involved in its conversion to hexose phosphate will be treated in subsequent publications.

What we would like to point out here is the fact that the first free carbohydrate which appears in these plants is sucrose. The positions taken on the chromatogram by free glucose and free fructose are known and they do not contain radioactivity. The nonappearance of radioactivity in a given compound does not necessarily preclude the possibility of its playing a part as an intermediate in a given sequence. For example, the reservoir of this compound in the sequence



C^{14} RADIOGRAMS OF 80% ETHANOL EXTRACTS OF ALGAE[1, 2]

A: 15-sec dark fixation by *Chlorella* which had been preilluminated for 15 min in helium. B: 5-sec photosynthetic fixation by *Chlorella*. C: 30-sec photosynthetic fixation by *Chlorella*. D: 90-sec photosynthetic fixation by *Chlorella* (10% of the activity fixed is insoluble in 80% ethanol). E: 5-min photosynthetic fixation by *Chlorella*[3] (60% of the activity fixed is insoluble in 80% ethanol). F: 5-sec photosynthetic fixation by *Scenedesmus*.[4]

[1] The term "radiogram" is used here to denote the radioautograph of a two-dimensional paper chromatogram.
[2] The abbreviations used in labeling the radiograms indicate the following compounds: PGA, phosphoglyceric acid; G-1, glucose-1-phosphate; G-6, glucose-6-phosphate; F-6, fructose-6-phosphate; p-MALIC, malic acid (position dependent on pH).
[3] Dotted circles indicate the positions of fructose and glucose which are not radioactive.
[4] Aspartic acid, encircled in the radiogram, was identified by ninhydrin spraying and has a small amount of radioactivity.

may be extremely small, or the compound may never exist as a free compound in solution but rather only as an enzyme-substrate complex, so that the amount of radioactivity present in that particular compound may be so small as to be missed. Conversely, the appearance of radioactivity in a particular compound does not necessarily prove its part as an intermediate in a direct sequence. It can be, and often is, the result of a side reaction.

It does not seem likely that, if free glucose or free fructose were intermediates in the synthesis of sucrose, they would fail to appear radioactive either prior to the appearance of radioactive sucrose or simultaneously with it, as is the case in the present experiments. We are, therefore, led to suggest that the immediate precursors to sucrose are two hexose phosphates. That one of them is glucose-1-phosphate can be taken as relatively certain in view of the large amount of radioactivity found in this compound, as well as its demonstrated participation in sucrose synthesis by an isolated enzymatic system (*5*). If the other is fructose-6-phosphate, which has also been identified among the radioactive compounds in the early chromatograms, one might expect a sucrose phosphate in which the phosphorus is attached to the fructose fragment as the intermediate just prior to the formation of free sucrose. Although it is not required that this intermediate be found, since dephosphorylation may take place simultaneously with the condensation to sucrose, there are still a number of unidentified spots in the chromatograms, one of which might well be a sucrose phosphate.

That the fructose phosphates are formed prior to the glucose derivatives is suggested by the fact that the fructose half of the sucrose formed in 30-second photosynthesis by *Chlorella* has approximately twice the specific radioactivity of the glucose half. This was determined by cutting out the sucrose spot from a chromatogram of the total extract, eluting it from the paper, hydrolyzing for 10 minutes in 0.1 N HCl at 80° C and rechromatographing the hydrolyzate after cold evaporation to dryness to remove the HCl. The sucrose formed in 90-second photosynthesis by the same organism is made up of glucose and fructose of equal specific activities (within 5%). This result requires that the functioning reservoirs of precursor hexose phosphates be so small as to achieve equal specific activities in 90 seconds.

Additional evidence for the size of the functioning reservoirs and the speed of turnover may be obtained from a knowledge of the molar specific activity of a compound relative to that of the fed carbon dioxide. One case in which this may readily be determined is that of alanine. Its position on the paper can be defined with reference to the radiogram. The spot is then eluted and the activity determined by counting an aliquot. The alanine content of the remaining solution is then determined colorimetrically. When this is done, the following very approximate values are obtained for the molar specific activity related to that of the starting carbon dioxide for various times of photosynthesis by *Chlorella*: 5 seconds, ~ .04; 15 seconds, ~ .1; 90 seconds, ~ .9; and 5 minutes, ~

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TECHNICAL PAPERS

Underwater Listening to the White Porpoise (*Delphinapterus leucas*)

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Recent developments in underwater acoustics have led to considerable speculation on the sounds made by cetaceans. Exclusive of those incidental to breathing or splashing at the sea surface, there is a variety of sounds which several species are known to make habitually while submerged. Published accounts allude to such sounds as heard through the air, but there seems to be no record of what can be heard by listening in the whales' own medium.

To learn more of the extent to which particular cetaceans do make underwater noises and how they sound under natural conditions on underwater listening apparatus, we wished to find an area where a single species was plentiful enough to be observed and listened to for relatively long periods. The white whale or porpoise, *Delphinapterus leucas* (Pallas), suggestively nicknamed "sea canary" (*1*, *2*), seemed a promising subject and was known to occur in large numbers in the St. Lawrence estuary. As suggested by Vladykov's recent comprehensive works (*10*, *11*) on this species, we found a good concentration in the lower Saguenay River in Quebec. The white porpoises were remarkably numerous, passing up and down the river in groups of various sizes throughout the day, so that we were able to listen to them for hours at a time, while watching them through field binoculars. Furthermore, no other cetaceans were observed there, although the little piked whale, *Balaenoptera acutorostrata* Lacépède, was seen in the St. Lawrence River a few miles away.

Our listening gear (a conventional underwater microphone, or hydrophone, with an amplifier) enabled us to hear over a frequency band between somewhat less than 500 and 10,000 cycles/sec, well within the normal human audible range. Strong currents, shoals, tide rips, and traffic in the St. Lawrence contributed to a noise background sufficiently high to interfere with our hearing. In the lower Saguenay the deep water (over 100 fathoms) and our good fortune in having little wind gave us the quiet essential for good listening, although there were two intervals with strong gusts of wind when the waves drowned out the sounds made by *Delphinapterus* nearby.

We found the water remarkably free of animal noise except when *Delphinapterus* were within range. Whenever we saw them we heard a variety of sounds which would become louder as the porpoises were seen coming around a bend in the river and would die away as they passed out of sight. But for the two occasions of rough water, we never sighted them without hearing them, and rarely heard them without seeing them, except after dark.

The noises which we thus ascribed to *Delphinapterus* were heard as high-pitched resonant whistles and squeals, varied with ticking and clucking sounds slightly reminiscent of a string orchestra tuning up, as well as mewing and occasional chirps. Some of the sounds were bell-like, and a few rather resembled an echo sounder. Occasionally the calls would suggest a crowd of children shouting in the distance. At times there were sharp reports, somewhat like a blow with a split bat or a slap on the water, although nothing could be seen to be striking the water in any way; perhaps this was jaw snapping, as reported for *Tursiops* by McBride (*8*, p. 25; *9*, p. 112). On two occasions we heard trilling, which quite justified the name "sea canary." This description is given with some diffidence in view of the notorious difficulty of adequately describing unfamiliar sounds. We hope to make phonographic recordings at another opportunity.

It is to be emphasized that all these sounds were made under water. We heard them only through the hydrophone, which was at depths of 60 to 90 feet; the porpoises were never nearer than about 200 yards, and often over two miles away. Mostly they passed along the far side of the river in their usual series of short dives (5–10 seconds' submergence, perhaps 50 feet of horizontal progression), but sometimes they would make unusually long dives (up to about half a mile) apparently to avoid us; in either case their calls continued uninterrupted. Axel Olsen and Léopold Boulianne, of Tadoussac, Province of Quebec, who accompanied us, said that they had previously heard whistles when *Delphinapterus* passed directly beneath their canoe, but that they had never heard such a variety of sounds as they now did over the underwater gear. Similarly, the underwater sounds heard by earlier authors (Fisher, *3*, *4*; Kane, *6*; Nielsen, *2*; and others, summarized by Vladykov, *10*, pp. 121–124) may be recognized among the list of those we heard, although no single listener seems to have heard them all, perhaps because they were handicapped by listening through the air instead of through the water alone.

[1] Contribution No. 460 from the Woods Hole Oceanographic Institution.

[2] The authors are indebted to officials of the Province of Quebec, especially to Dr. Vadim-D. Vladykov, of the Department of Marine Fisheries, for cordial advice and assistance, to Mr. Charles Frémont, General Superintendent of Game and Fisheries, and to Dr. Robert Lagueux for his hospitality at the Tadoussac Fish Hatchery.

Since fish noises predominate in other regions, it seems strange that none were identified here, except for those caused by their biting and pulling at the hydrophone. It is possible that some of the sounds might be of fish origin, but it is significant that only the bites were detected in the absence of *Delphinapterus*.

Particularly striking is the great variety of *Delphinapterus* sounds and their rapid and apparently continuous succession. This loquaciousness contrasts markedly with most terrestrial herd mammals and compares with such chatterboxes as monkeys and men. Among the Cetacea it would appear not to be limited to *Delphinapterus,* as is indicated by the continuity of related but less varied sounds heard by one of us in the presence of different porpoises in the open Atlantic, as well as those on phonograph records at the Woods Hole Oceanographic Institution which are believed to be of porpoises. The considerable difference between the sounds we heard in the presence of *Delphinapterus* and the less spectacular ones associated with *Delphinus* (Kullenberg, *7*; Fraser, *5*), *Tursiops* (McBride, *8*, p. 19; *9*, pp. 112–113), and other pelagic forms encourages us to hope that these underwater calls may be sufficiently characteristic to be helpful in distinguishing cetaceans at sea. Such listening probably will have to be carried into the supersonic range.

Only toothed whales (Odontoceti) have figured in the reports so far encountered. It would be of interest to learn of any authenticated instances of hearing underwater sounds from baleen whales. Among these, our experience with listening apparatus is limited to the solitary individuals of *Balaenoptera acuto-rostrata* mentioned earlier; we distinguished no underwater sounds even when a whale was within 300 yards.

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Colorimetric Estimation of Succinic Dehydrogenase by Triphenyltetrazolium Chloride[1]

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Methylene blue or other redox dyes are extensively used as indicators of dehydrogenases. Enzyme activities are frequently defined by the anaerobic decolorization time of a redox dye, but photometric estimation of the decolorization can be carried out in special Thunberg tubes only if the reaction mixture is not very turbid (*1*). It was found in our laboratory that triphenyltetrazolium chloride is a suitable indicator of the succinic dehydrogenase activity of tissue homogenates. The advantages of this technique are that the system does not require anaerobic conditions and that the enzyme activity can be followed quantitatively by colorimetric measurements.

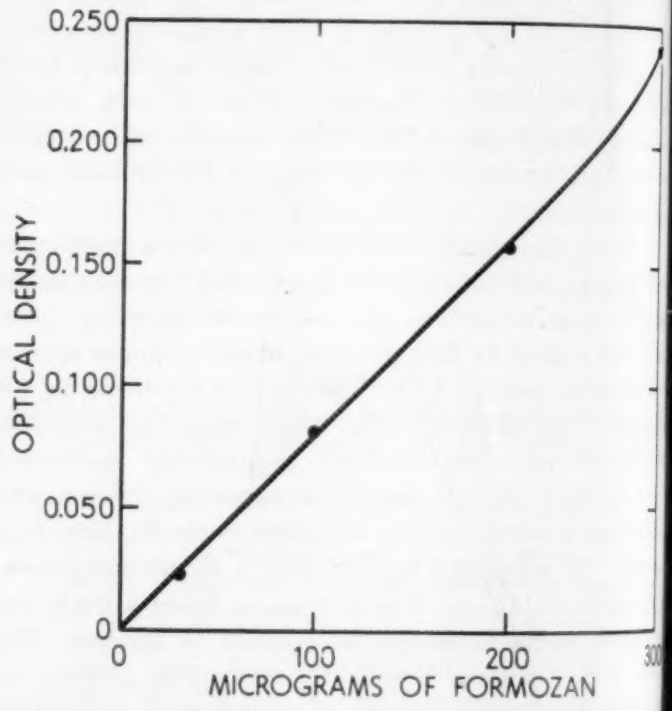

Fig. 1. Straight line relationship between the amount of reduced tetrazolium salt (formozan) and optical density (log I_0/I_x).

Tissue homogenates in the presence of succinate in a buffered (pH 7.4) medium reduce the colorless tetrazolium salt to a red water-insoluble formozan. The formozan (*2*) can be easily dissolved in acetone, which by precipitating tissue proteins, leaves a clear supernatant ready for colorimetric measurement. Under given conditions, in the absence of succinate the tissue homogenates tested do not reduce the tetrazolium salt except under strongly alkaline conditions.

If this principle is applied, the colorimetric determination of succinic dehydrogenase can be carried out according to the following procedure: Into 15-ml calibrated centrifuge tubes are pipetted 0.5 ml of 0.1 M phosphate buffer (pH 7.4), 0.5 ml of 0.2 M sodium succinate, 1.0 ml of 10% tissue homogenate (*i.e.* 0.1 to 1.0 ml of homogen-

[1] This investigation was supported by a grant from the Office of Naval Research, N60RI-20, Task Order #11.

ate, depending on the enzyme content, made to 1.0 ml with distilled water), and lastly 1.0 ml of freshly prepared 0.1% triphenyltetrazolium chloride solution. After shaking, the tubes are placed in a constant temperature bath at 38° C for a period of 15 to 30 min. Immediately after removal of the tubes from the bath, 7 ml of acetone are added and the tubes are stoppered and shaken vigorously. The precipitate is then centrifuged, and the clear supernatants are drawn off for the determination of optical density. The color is stable for several hours and can be measured by the Klett photometer using a 420 filter. There is a linear correlation between the amount of dye and optical density (log I_0/I_x) in the range between 20 and 300 μg. To obtain a calibration curve, varying amounts (20 to 300 μg) of tetrazolium salt are reduced by a few crystals of sodium hydrosulfite in the system as described (Fig. 1). Furthermore, the amount of dye measured by optical density is a linear function of the amount of enzyme present (Fig. 2). The

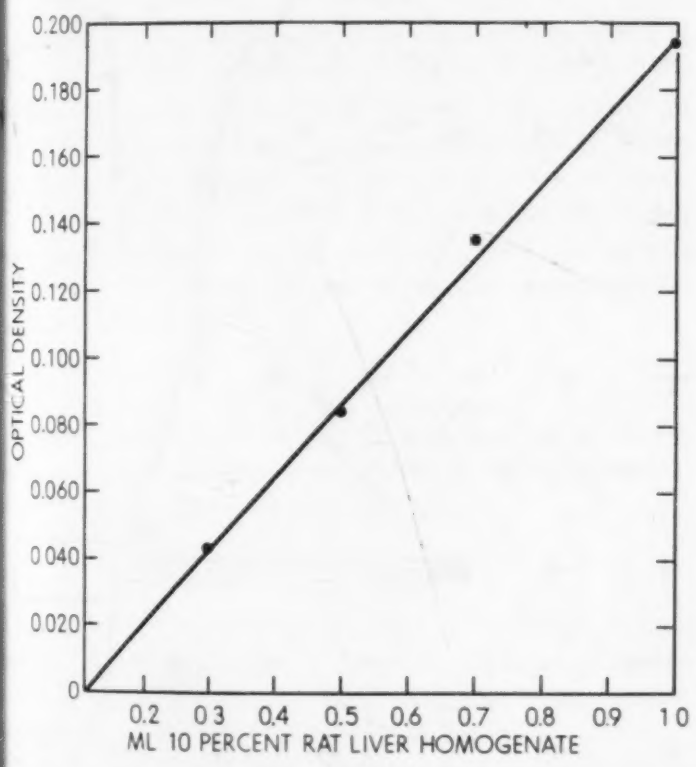

FIG. 2. Straight line correlation between the amount of enzyme (rat liver homogenate) and the amount of reduced tetrazolium salt, as measured by optical density. Time of incubation, 10 min; temperature, 38° C.

rate of reduction of the dye gives a curve resembling that of most enzymatic reactions. During the first 30 to 40 minutes the curve is approximately linear. Under anaerobic conditions (nitrogen) the rate of reaction is initially greater, while tending to decrease more rapidly (Fig. 3).

In view of these findings it is quite simple to determine quantitatively the succinic dehydrogenase activity of tissue homogenates. The enzyme activity of various tissues may be expressed in terms of micrograms of dye reduced in 10 minutes by 1 milligram of tissue; however, it is necessary to take into account the unequal adsorption of the dye by equivalent amounts of different tissues. Consequently, two controls are run with the unknown; the first contains no succinate and serves as a tissue blank, while the second also contains no succinate but a

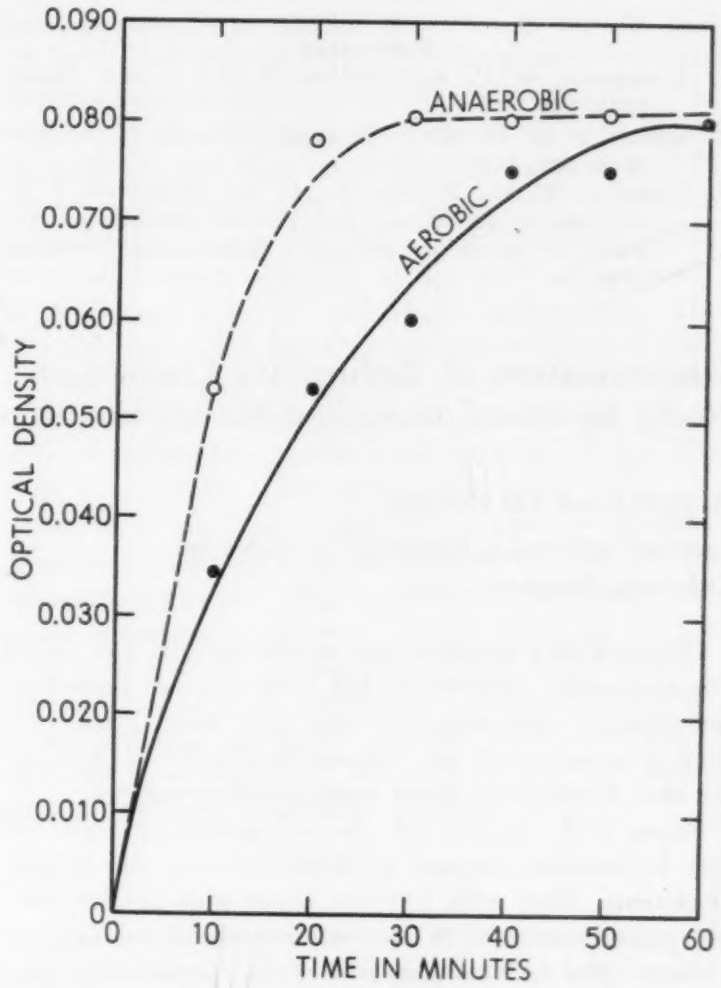

FIG. 3. Comparison between the rate of reduction of the tetrazolium salt by 0.25 ml of 10% rat liver homogenate under aerobic and anaerobic (N_2) conditions.

given amount, viz., 100 μg, of the tetrazolium chloride which is reduced by sodium hydrosulfite. The latter is the reference standard for a specific tissue. The experimental tube contains all the constituents. Typical experimental data obtained with 10% homogenates of rat kidney, liver, brain, heart, and testis are presented in Table 1.

This method can be used in the study of enzyme inhibitors. Sodium malonate (0.5 ml of 0.1 M solution)

TABLE 1

Tissue	μg of dye reduced/ mg of tissue*/10 min
Kidney	1.72
Liver	1.56
Brain	1.00
Heart muscle	0.75
Testis	0.43

* Wet weight.

produces a 75% inhibition of the succinic dehydrogenase activity of rat liver homogenate (0.5 ml of 10% homogenate); ethyl urethane (0.5 ml of 2% solution), 46% inhibition. Cyanide (1%) on the other hand causes no inhibition. Triphenyltetrazolium chloride does not interfere with succinate oxidation by tissue homogenates either

in the absence or in the presence of added cytochrome C, as measured in the Warburg apparatus (*1*).

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Determination of Radioactive Content of Rocks by Means of Geiger-Müller Counters

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Geiger-Müller counters are widely used in the search for radioactive substances, but their use for immediate quantitative determination has not been elaborated. During a survey of the Velence Mountains in Hungary we have developed a direct approximating method.

Brass G-M counters of the self-quenching type (45 mm in diameter, 88 mm in length and 1.8 mm in wall thickness), filled with 100 mm argon and 10 mm alcohol vapor, were used in connection with all battery amplifiers. The soft components of the γ-radiation were absorbed by a 2 mm-lead shield. In this way only the known penetrating γ-components of the known radioactive bodies (uranium, thorium, their decay products, and potassium) could reach the counter.

In most cases the counter was placed touching the rock wall to be investigated, but in one instance, we drove a bore, 5 cm in diameter and 50 cm deep, into the granite wall and placed the counter within. The counting rate (number of impulses/min) was determined and compared with the counting rate of the cosmic radiation, the last amounting to 40/min. We subtracted this value from the observed total counting rate, and divided the remaining rock-activity counting rate by this factor. We observed that the counting rate was about 6 times higher in the bore and 2–3 times higher immediately at the wall than the cosmic radiation. The activity of the rocks can be expressed approximately by this factor, and this kind of expression is, within some limits, independent of the counter dimensions. It can be used for comparison of measurements made by various brass counters. However, it is not independent of the material of the counter, because the γ-sensitivity of a G-M counter depends upon the atomic weight of its substance. As is known, the intensity of the cosmic radiation depends upon the geographical latitude. In this case it amounted to about 1 impulse/min · cm² of maximum square area of the counter (length × diameter).

The observed γ-radiation of rocks may originate from K, U, and Th, and their decay products in equilibrium. ThC″, RaB + C and K are the sources of the hard γ-radiations, which affect the counter under such conditions. Softer components may have a minor part only, for they are absorbed by the lead shield, and the sensitivity of a brass counter is small for soft γ-rays.

Now it must be realized, that the direct determination of the proportion of the existing radioactive substances to each other in the rock is hardly possible with a G-M counter without any chemical separation. It is possible, however, to determine the total radioactivity of the rocks expressing it in Th-γ-equivalents, as measured by a brass G-M counter behind a 2-mm lead shield. We achieved it in the following way: It is possible to calculate the total amount of the hard γ-radiation that reaches the counter from the surrounding rock substance. In Fig. 1 we have

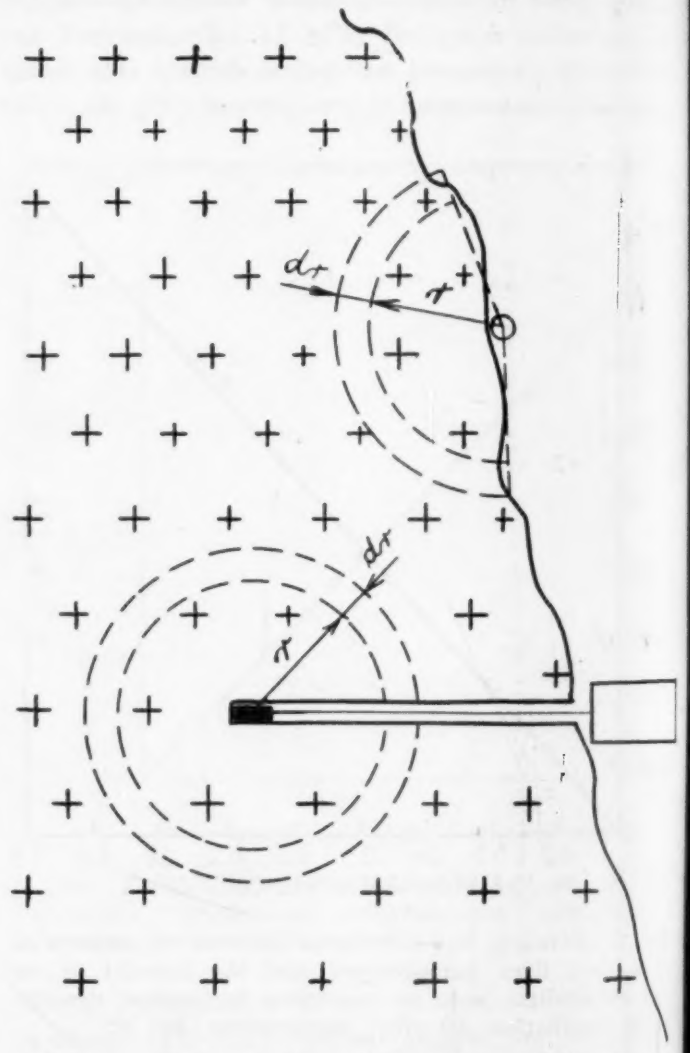

FIG. 1. Determination of Th and U concentration in rocks by a G-M counter tube.

taken the center of our coordinate system as the middle of the counter in the bore. (The counter may be regarded as small in comparison with the surrounding rock masses.) A small volume, dv, of the rock containing c g-Th-equivalents of radioactive substance/cm³ rock, will send a penetrating γ-radiation from r distance to the counter, giving the counting rate, dJ. It is obvious that $dJ = cA\,dv/r^2$, where A is the sensitivity of the given counter, that is, the rate of counting when 1 g Th (in radioactive equilibrium) is placed 1 cm from the counter.

Now we must take into account the self-absorption of the γ-radiation within the rock substance itself. The

γ-quanta traverse the distance r in rock and not in space, thus the counting rate is diminished by a factor of $e^{-\mu r}$, where μ is the absorption coefficient, expressed in cm^{-1}. For simplicity of calculation of the volume element, dv, we choose the spherical shell of radius r; the thickness of it being dr: $dv = 4\pi r^2 dr$. Taking the self-absorption into account, the counting rate is

$$dJ = \frac{cA4\pi r^2 e^{-\mu r}\, dr}{r^2} = 4\pi cAe^{-\mu r}\, dr.$$

We take the integral over the infinite space filled with rock and obtain the total counting rate:

$$J = \frac{4\pi cA}{\mu}.$$

We are actually interested in the concentration c, which is expressed here in g/cm^3. It is more usual to express it c' in g/g of rock, if ρ is the specific density of the rock in g/cm^3.

$$c' = \frac{c}{\rho} = \frac{\mu J}{4\pi A\rho}.$$

The absorption coefficient above is expressed in cm^{-1} and refers to the rock substance. It can be determined experimentally by using a known amount (about 10–50 g) of old Th-compound, or we can calculate it reliably, knowing its value in lead, $\mu_{Pb} = 0.46\ cm^{-1}$ (with 2 mm of lead). By dividing it by the specific density of lead we obtain the so-called mass-absorption coefficient; multiplying this by the density of the rock, we obtain the absorption coefficient in the rock

$$\mu = \frac{\mu_{Pb}}{11.3}\rho$$

If the absorption coefficient in lead is substituted, the formula takes a simpler form, in which the specific density of the rock does not play any role:

$$c' = \frac{\mu_{Pb} J}{4\pi 11.3A}$$

The counter sensitivity, A, was determined experimentally by placing 10 g of old ThO_2 at 30 cm distance from the center of the counter. For our brass counter its value was $4.8 \cdot 10^3$ impulses/g of Th · min.

We calibrated the same counter in U-equivalents as well, using instead of U, about 0.01 mc of radium in radioactive equilibrium. As the penetrating γ-radiation originates from RaB and RaC, the γ-radiations of the decay products between U and Ra can be neglected (1 g of Ra is equivalent to $3 \cdot 10^6$ g of U in radioactive equilibrium). The value for μ_{Pb} is known to be $0.53\ cm^{-1}$ in lead. We obtained a value for A of $9.3 \cdot 10^3$ impulses/min · g of U at 1 cm distance from the given counter.

As can be seen, the estimation gave for the Th-U equivalent a value of 1.9, that is, 1.9 g of Th gives, in this brass counter, the same rate of counting as 1 g U (in radioactive equilibrium with their decay products).

The method outlined above was checked experimentally by our measurements on a granite wall near the village of Velence in Hungary. We obtained, with the counter in the bore, $12 \cdot 10^{-5}$ g-Th-equivalents/g of granite for the total concentration of the radioactive bodies. Careful laboratory tests were carried out later on a sample taken from the same granite wall. It was dissolved completely and the equilibrium of radon and thoron content determined separately, by means of an ionization emanometer. These measurements yielded $4.2 \cdot 10^{-5}$ g of Th and $0.87 \cdot 10^{-5}$ g of U/g of granite. The granite of these mountains contains about 3.9% K as determined by A. Vendl (*5*). The K-U equivalent was determined by F. Behounek (*1*) and more recently by E. Gleditsch and T. Graf (*2*). The γ-radiation of K is equivalent to 4.10^{-4} g of U/g of K. Expressing the U and K content of the granite in Th-equivalents, we obtain good agreement of the two entirely different methods of determination. The difference lies in the fact that the counter gives a mean value for the concentration within a sphere of a diameter of about 60 cm surrounding the bore, but the emanometric measurements indicate the activity of the dissolved sample to be about 4 g of granite.

Now in a practical search for radioactive content, higher concentrations must be considered. The K content can be neglected. Any commercial G-M counter tube can be calibrated in the way outlined above by the use of about 10 g of old Th compound and/or about 0.01 mc, calibrated Ra source in equilibrium. With a brass counter, not differing too much from the dimensions above, calibration is not essential. One may use our calibration, expressed by the approximate numerical formula:

$$c = \frac{0.46 \cdot 36.4J}{4\pi LD4.8 \cdot 10^3 \cdot 11.3} = 2.4 \cdot 10^{-5}\frac{J}{LD}$$

where c is the concentration in g-Th-equivalents/g of rock; J, the counting rate (in min); L the length; and D the diameter (in cm) of the brass cathode of the counter tube. Similarly, we obtain the concentration in g-U-equivalents/g of rock by the approximate numerical formula:

$$c = 1.4 \cdot 10^{-5}\frac{J}{LD}$$

If the measurements are made without use of the bore, the counter is put as near as possible to the wall, and there is a loss of 50% or more in the counting rate, depending upon the geometry. The accuracy is reduced by the fact that the geometry is not so well defined as in the case of the bore, but the formula can be used, approximately, by multiplying the counting rate by a correction factor of about 2–2.2.

Further, the use of the following roughly approximating simple rule may be suggested for uranium explorers when extended territories must be surveyed within a short time: If a G-M counter of any commercial dimensions, shielded by 2 mm of lead, is placed against the rock wall and the observed counting rate (minus cosmic radiation) is x times the rate of cosmic radiation for the same counter, then the average U concentration in the rock is x times 25 g U/metric ton (1,000 kg) of rock.

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An Ostreodynamometer for Studying the Activities Inside the Shell of Bivalve Mollusks[1]

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In conducting investigations on the effects of industrial pollution on oysters, it was considered necessary to develop an instrument capable of detecting movements within the shell without interfering with an oyster's normal activities.

The ideal method of recording cardiac, pericardial, visceral, or branchial activity should continuously yield data on the influence of chemical agents on the nature of activity in various tissues and organs. Thus, several indices could be established and compared to the activities occurring in a normal sea-water environment.

The instrument which we have devised (Fig. 1) records such activities electrically. Shell movements are recorded synchronously by a mechanical system. The principle involves the application of the carrier system of electronic amplification to direct recording, as used in strain-gage techniques. The key to the method is the specially devised pickup by which the imperceptible movements of a probe can unbalance a Wheatstone bridge.

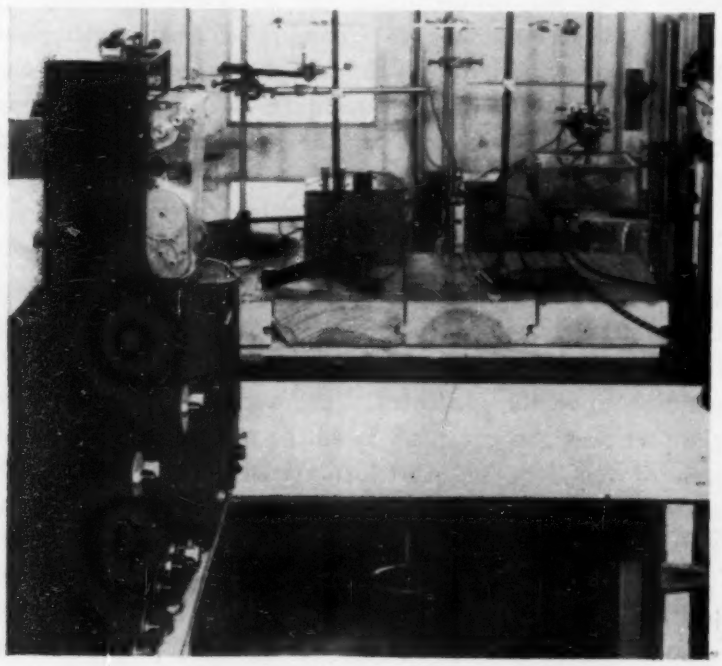

FIG. 1. The ostreodynamometer in working position. Power supply and amplifier (left); pickup device and salt-water distribution tanks (right).

Prior to the actual operation of the instrument, a small hole (1.5 mm) is carefully drilled through the valve of the oyster at the approximate position of the organ to be studied. The oyster is then allowed to recover until the thin prenacreous membrane has been formed. A natural

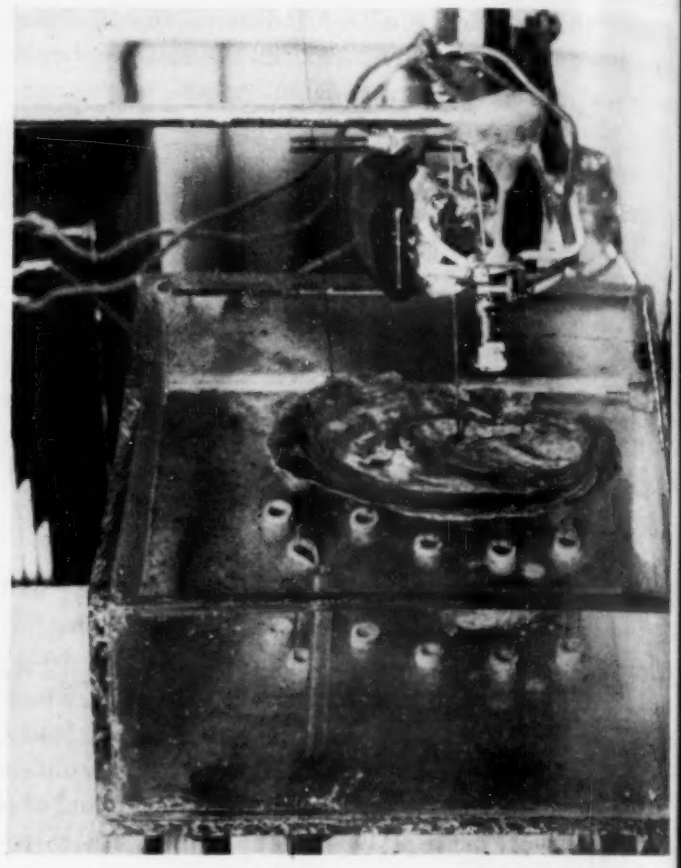

FIG. 2

membrane is thus utilized for the transmission of organ pulsations, e.g. cardiac, to a counterbalanced probe resting on the membrane.

The pickup mechanism in operation is shown in Fig. 2. The probe consists of an aluminum rod to which is attached a 10-mm fragment of silica steel and which, in turn, is counterbalanced by a simple lever. The steel fragment is inserted midway between the core of the detector coils and is equal in length to the thickness of one coil.

Two 6,000-ohm coils, adjacently connected, serve as the basis for the detection of kinetic activity. The fragment of steel transmits the mechanical movements of the probe. The coils are connected in a conventional Wheatstone bridge circuit in such a manner that, as the impedance of one increases, the impedance of the other decreases. The over-all current in the bridge circuit is thus held constant at the generator position, but variations in voltage are present at the detector. Since the impedance of each coil varies with the position of the probe, its fluctuations caused by the organ pulsations are converted into corresponding fluctuations of impedance. Since the current through the coils is constant, in accordance with Ohm's law, there is a fluctuation in voltage at the output of the bridge. This variation in voltage is proportional to the amount of movement of the probe.

Because the coils are adjacently connected, they cancel out stray magnetic interference and changes in impedance caused by variations in temperature.

[1] This instrument is being used at the laboratory of the U. S. Fish and Wildlife Service, Pensacola, Florida, in space allocated to the State of Louisiana for the purpose of conducting independent investigations.

A well-regulated power supply and a 1,000-cycle oscillator are constructed on one chassis; a second chassis contains the amplifier and the detecting system. The power supply itself is a conventional full-wave unit with choke input filtering, anti-jitter type of voltage regulator, a Wein bridge-type oscillator, and a single-tube buffer amplifier, coupled to the input position of the Wheatstone bridge. The output of the bridge is connected to the input of a three-stage voltage amplifier, with a degenerative type of step gain control. This degeneration control serves to regulate the amount of deflection on the recording pens per kinetic unit of the bivalve. The voltage at the input of the amplifiers consists of a 1,000-cycle "amplitude modulated" audio note, with its amplitude varying in proportion to the internal movements of the oyster. Amplitude variations are removed by simple detection with dry disk rectifiers, whose output is sufficient to operate the recorder.

The recorders are the Esterline-Angus type with multiple ranges of 1, 5, and 10 ma. At these values the recorder requires a 2-v emf. This is derived from the

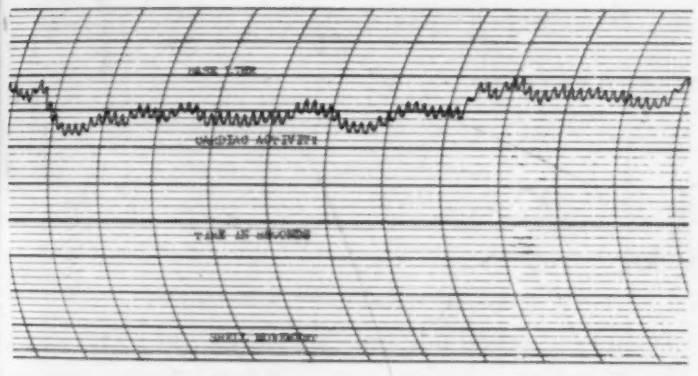

FIG. 3. An ostreodynagraph. The oyster shell is open. Total time of sample record, 3 min.

detector through the final tube of the power amplifier. In series with the recorder is the monitor meter which is used to balance the bridge and bring the output to a value within the range of the recorder.

In operation, the probe and coils are adjusted to fit the individual oyster (Fig. 2). The probe is adjusted so that the balance is slightly in favor of that part resting on the prenacreous membrane. The sensitivity of the pickup mechanism permits detection of slight rotational movements as well as the vertical movements of the probe.

The pen of the recorder can be controlled by the balance unit on the amplifier, allowing a base line to be set in any position. The amplitude of the recording can be regulated by varying the feedback in the amplifier or by varying the milliamperage range of the recorder. The bridge is operated slightly off balance so that the entire motion of a particular organ can be recorded without distortion (Fig. 3).

This instrument has been named an ostreodynamometer (ostreo—oyster; dynamometer—measurement of force). The records obtained are ostreodynagraphs.[2]

[2] Name suggested by S. R. M. Reynolds, *et al. Science*, 1947, **106**, 427.

The range of applications of the ostreodynamometer will have to be determined by use. Various types of strain gages, capillary columns, resistance pickups, or any conversion element changing to electrical impedance, can be substituted for the detector coils.

Its value at the present time lies in the fact that for the first time the encumbrances of the shells have been circumvented, making it possible to study the physiological processes of mollusks with a minimum of injury.

A detailed report of the construction of this unit, including wiring diagrams and drawings, will be made in another journal.

The Osmotic Activities of Sodium Penicillins F, G, K, and X[1]

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By means of surface tension measurements in 1947 Hauser, Philips and Philips (*2*) found that solutions of sodium penicillin G have a high capillary activity, a fact which led them to believe that such solutions are colloidal sols and not true solutions. Woodbury and Rosenblum, however, (*7*), have made conductivity measurements over a range of concentrations of sodium penicillin G and found that the salt behaves as a completely dissociated electrolyte of the 1:1 valence type, with possible deviations due to ion size and interactions. In 1948 Kumbler and Alpen (*4*), employing both du Noüy's precision tensiometer and the capillary rise method, carried out surface tension measurements on aqueous solutions of crystalline sodium penicillin G and crystalline potassium penicillin G and found that solutions of penicillin G have a surface tension differing only little from that of water. Therefore, the solutions must be true solutions and not colloidal sols.

In the following we shall give an account of some experiments on the osmotic activity of penicillin solutions

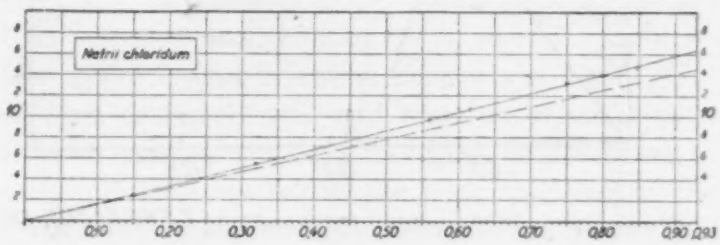

FIG. 1. Freezing point depression in °C (abscissa); concentration in 0.1 per cent (ordinate).

using relative vapor-pressure measurements, in order to throw more light on the subject by means of a third method of measurement, in addition to the two referred

[1] We wish to express our gratitude to the Antibiotic Study Section of the National Institutes of Health, U. S. Public Health Service, for the supply of crystalline penicillins F, G, K, and X used in these studies.

to above. In 1946 we examined the osmotic activity of the commercial penicillin preparations then obtainable, varying widely as they did in purity; pure sodium penicillin G was not available to us at that time (*5*). We had no doubt that a solution of sodium penicillin must be a true solution rather than a sol and would consequently have measurable osmotic activity. Some relative vapor-pressure measurements of pure crystalline sodium penicillins F, G, K, and X were made as follows.

For determining the relative vapor pressure of the solutions we employed Baldes' (*1*) modification of the method described by Hill (*3*). The apparatus consisted of a thermoelement with two small eye-shaped solderings capable of being enclosed in a small metal container, the walls of which are covered with filter paper.

For taking a measurement a small drop of the solution to be tested is placed in one eye and a similar drop of a standard solution in the other; the filter paper on the wall is also moistened with the standard solution. For the standard solution we take whichever concentration of a series of sodium chloride solutions (0–0.5, 1.0–1.5 to 15.0%) is presumed to have a vapor pressure of the same order as that of the solution to be tested. The thermoelement is then placed in a Dewar flask with water to ensure that the measurements can proceed at a constant temperature, and connected with a sensitive gal-

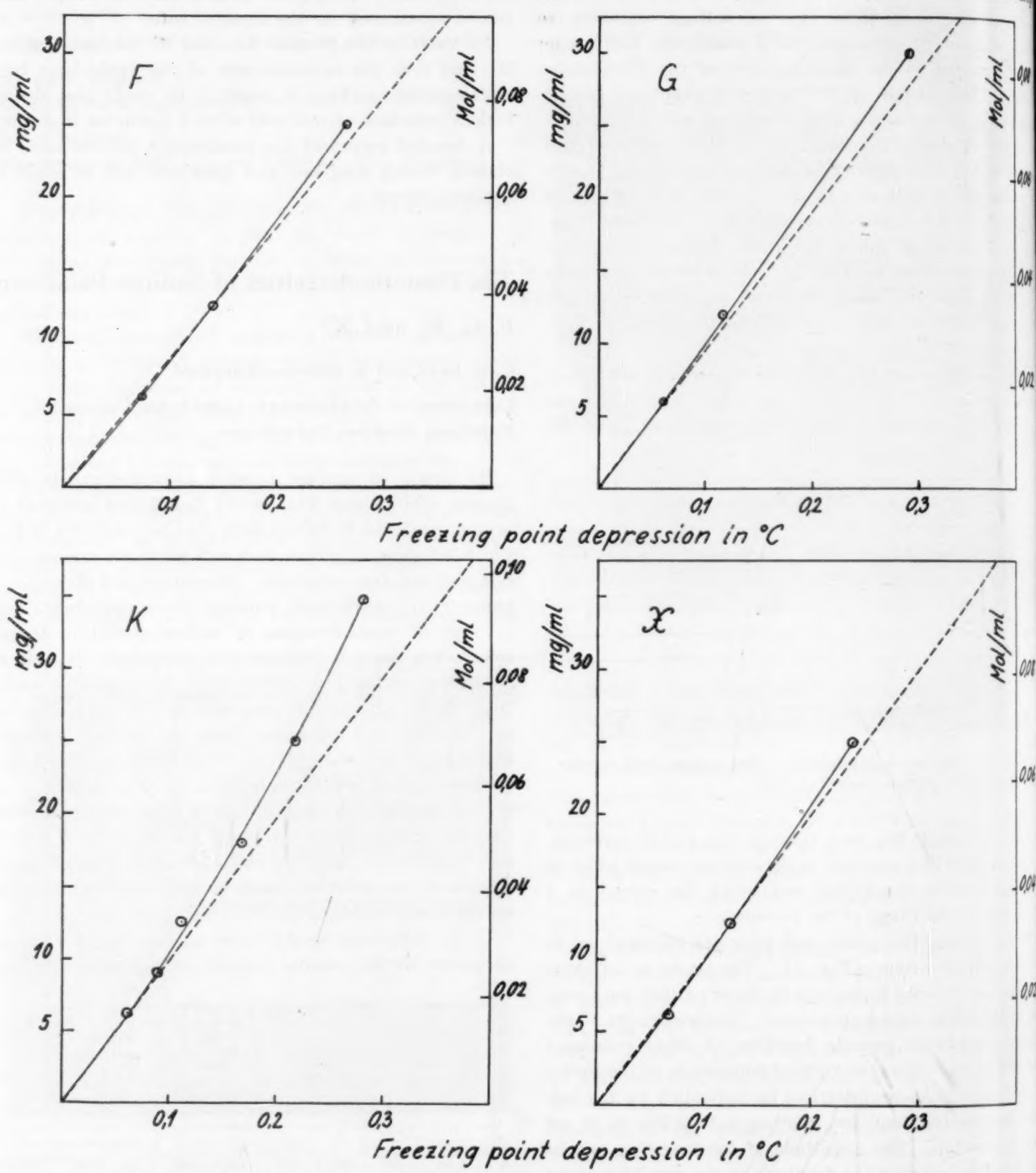

FIG. 2. Freezing point depression of aqueous solutions of sodium penicillins F, G, K, and X.

vanoscope. If the two drops represent solutions of different osmotic pressures, evaporation from the drops will differ. That having the lower osmotic pressure will evaporate more rapidly and thus become cooler than the other. The difference in the temperatures will generate a thermoelectric force which will register on the galvanoscope. By these measurements we then find the two successive standard solutions between which the vapor pressure of the test solution lies, and, with the aid of the registration values, we can by interpolation calculate the sodium chloride concentration that gives the same vapor pressure as the test solution. From this concentration, by employing the relation between sodium chloride concentration and freezing point depression (see Fig. 1) previously described (*6*), we can find the freezing point depression which the particular solution would give. The uncertainty in this determination is about ±5%.

From the sodium salts of the penicillins we prepared aqueous solutions with 6.25–36.0 mg/ml solution.

In Fig. 2 the results found experimentally and converted to freezing point depressions are plotted as small circles. The continuous curves in the figure are drawn by transferring point by point the straight lines connecting the circles in a double logarithmic coordinate system to the arciform curves seen in the arithmetic system employed in Fig. 2. The relation between the concentration and the molar freezing point depression, calculated by Raoult's law, is shown in stippled curves.

The osmotic coefficients for 0.05 molar solutions of sodium penicillins F, G, K and X are as follows: F, 0.98; G, 0.94; K, 0.88; and X, 0.97. It will be seen that the osmotic coefficients for pencillins F, G, and X amount to 0.94–0.98, which corresponds to that for a 0.05 molar solution of sodium chloride. In a 0.05 molar aqueous solution of sodium penicillin K the osmotic coefficient is lower, 0.88, corresponding to the osmotic coefficient in a 0.05 molar solution of lobeline-hydrochloride. The low osmotic coefficient shown by the K penicillin is possibly due to the long heptyl chain in this molecule.

Not only the high value found for the osmotic coefficient, but also the fact that the osmotic coefficients of the sodium penicillins are of the same order as other dissociated electrolytes of the 1:1 valence type in similar concentrations, shows that these are true solutions.

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(*Continued from page 139.*)

movements of the limbs, causing the horse to roll over and over, were precisely those which are to be observed in the death struggle of a rabbit shot through the cerebellum."

D'Arcy Thompson was made Companion of the Bath in 1898 during Queen Victoria's reign, elected to the Royal Society in 1916, created knight in 1937. He received the degrees of D.Litt. (Cambridge), Hon. D.Sc. (Dublin and Witwaterstrand) and LL.D. (Aberdeen and Edinburgh). He was vice president (1931–38) and president (1934–39) of the Royal Society of Edinburgh. He was awarded the Darwin Medal in 1946. He was foreign correspondent and honorary member of a number of learned societies.

One spring morning in Paris, walking on the crowded boulevard, I heard my name called and saw a towering figure with massive sculptured head and long flowing beard, dart out from the tables of a sidewalk cafe. He greeted my wife, seized our hands, and pushed us into chairs. Seated opposite us, Sir D'Arcy, with no further ceremony, began to read to us a funeral oration that he was working on!

His last visit to this country was in 1936 on the occasion of his delivering six Lowell Institute Lectures in Boston, 79 years after his father had been invited to the same Institute. The subject matter of Sir D'Arcy's lectures is included in his book on Growth and Form. On his leaving New York for Scotland I went to see him off and found him on board with Leo Hendrik Baekeland, of Columbia University, the inventor of Bakelite. During the conversation, Professor Baekeland, who was 74 years of age at the time and only 3 years younger than Sir D'Arcy, remarked on my callow youthfulness in the presence of two septuagenarians. Sir D'Arcy, gazing at the magnificent panorama of New York from the Jersey shore said: "My hope is that I shall die young!"

Happily, he maintained his "youth" and at the age of 86 accepted an invitation to be one of four delegates to the Indian Scientific Congress in Delhi. He had been extremely well and was full of enthusiasm at the thought of ten days in Egypt before flying to India. But on his return the wear and tear of the journey had so depleted his strength that he was unable to recuperate from a protracted siege of pneumonia. He died June 21, 1948.

Sir D'Arcy was a man of the world, at home everywhere and with all conditions of people. He was a man of deep conservatism but with a quality of delightfully disarming revolt against the conventions. He had an inexhaustible sense of humor with touches of the oratorical, and was always an interesting companion and a solid friend.

Book Reviews

Radioactive indicators: their application in biochemistry, animal physiology, and pathology. George Hevesy. New York-London: Interscience, 1948. Pp. xvi + 556. (Illustrated.) $10.00.

The first application of tracer methods in biological research was made by Prof. Hevesy in 1923. With this book Prof. Hevesey—whose achievements as both initiator and foremost exponent of the use of tracer methods in many aspects of physiology and biochemistry were recognized in 1943 with the award of the Nobel Prize in chemistry—has marked the 25th anniversary of his fathering of tracer methodology. The subject matter is organized meticulousiy to cover tracer researches in animal physiology, biochemistry and pathology and is presented with characteristic lucidity. It has been announced that a volume dealing with plant physiology is in preparation.

Topics treated most thoroughly relate to the interest of Hevesy and his collaborators in investigations of whole organisms. There is an amazingly complete coverage of literature dealing with absorption, retention, turnover, and excretion of various metabolites, particularly those involving the mineral components phosphorus, iodine, and iron. Much data previously available only in journals difficult to obtain are made easily accessible for the first time.

The mere inclusion of such a wealth of material (over 900 references are cited) has involved an enormous amount of work, since no small fraction of the data undoubtedly required considerable reworking for adequate treatment. Insofar as is possible, an integrated presentation of these data has been undertaken. Extensive treatment of the fundamental concepts involved in tracer work, however, has not been possible. The over-all result is a volume with an appearance perhaps more of a compendium or reference than a text. In any case Dr. Hevesy has performed an extremely important service in bringing a measure of order into the chaos of literature dealing with tracer researches on absorption and turnover.

The merits of this treatise might be enhanced by a few shifts in emphasis. Thus, although detailed descriptions of mechanical devices, such as those used for automatic counting, are provided, fundamental phenomena and considerations relating to functioning of assay instrumentation are accorded either brief or only passing mention. For example, the correction for nonlinearity of response of a G-M counter at high counting rates is remarked only in one brief sentence in small print (p. 52). The statistical nature of G-M counter determinations is treated in a single page. The discussions of various formulas relating to turnover calculations should also have been extended.

There is evidence of very careful proofreading. Grammatical errors, as well as errors in references cited, are surprisingly few for a first edition. Tables and figures are clearly reproduced. An added feature is the inclusion of an isotope chart as compiled by E. Segrè.

MARTIN D. KAMEN
Washington University

Pulse generators. G. N. Glaso and J. V. Lebaeqz. (Eds.) New York-London: McGraw-Hill, 1948. Pp. xiv + 741. (Illustrated.) $9.00.

This book is volume 5 of the excellent MIT Radiation Laboratory Series of 28 volumes describing radar and radar techniques. While the title is probably reasonably apt for those who have not been in the radar field, most radar workers would have chosen "Magnetron Modulators" as a title. Virtually everything in the book relates to current-voltage pulses of duration and magnitude found convenient for radar magnetrons during the war, and devices for producing such were usually called modulators.

Specifically, the range covered in this book is from about .03 to 5 microseconds' duration, 1 to 60 kv on voltage and from 100 watts to 20 megawatts on power. This material is covered in 15 chapters which are broken up into three groups. In the first group is "The Hard Tube Pulser," which uses a vacuum tube as a switch to connect and disconnect an energy storage device (usually a simple condenser) and the load. The second group considers "The Line-Type Pulser," in which an artificial transmission line not only stores the energy but also determines the pulse shape on being connected to the load by means of a spark gap or hydrogen thyratron. The third group of chapters presents "Pulse Transformers." There are also appendices on "Measurement Techniques" and "Pulse Duration and Amplitude."

As a whole the book is very well done and the present reviewer has found it useful, interesting, and informative. Especially noteworthy is the fact that, in spite of the rather large number of contributing authors (13), there appear to be neither large gaps nor duplications.

On the other hand, much of the section on pulse transformers has been spoiled, for the present reviewer, by the author's "explanation" of many formulae by a rather nebulous analogy between thermodynamics, or possibly statistical mechanics, and transformers. This analogy is perhaps most clearly stated on page 501, and the fact that this assigns two degrees of freedom to a single mesh circuit does not inspire confidence. The analog is used to "explain" a result usually derived by the maximum-minimum methods of first year calculus. In fact, all the results the reviewer has checked seem to be correct, but because of the "thermodynamic" reasoning, the reviewer will not feel that the statements in these chapters are reliable for quick reference until he has verified them.

WILLIAM W. HANSEN
Stanford University

NEWS and Notes

Serge Korff, physicist at New York University College of Engineering, left for Europe on January 25 to continue his studies of cosmic rays. He will compare his test data with those of scientists at laboratories in Italy, France, Switzerland, Denmark, Sweden, and England to determine whether cosmic rays differ in intensity at various geographic locations.

Henry W. Fowler, curator of fishes in the Academy of Natural Sciences of Philadelphia, is making a 4-month study of the fresh water fishes of Colombia, particularly those in the headwaters of the Atrato, Magdalena-Cauca, Orinoco, and Amazon Rivers. His expedition is supported by a grant from the American Philosophical Society.

Maurice M. Shapiro, physicist at Oak Ridge National Laboratory, has been appointed head of the section on heavy-particle physics in the Nucleonics Division of the Naval Research Laboratory, Washington, D. C.

Appointment of **Harvey A. Neville** as dean of the Lehigh University. Graduate School and **Robert P. More** as associate dean of the College of Arts and Science was recently announced. Both appointments will become effective July 1.

Arthur B. Lamb, of Harvard University, will retire from the editorship of the *Journal of the American Chemical Society* at the end of this year. His successor will be W. Albert Noyes, Jr., of the University of Rochester, son of the editor whom Dr. Lamb succeeded in 1918. Both Dr. Lamb and Dr. Noyes are former presidents of the Society. Dr. Lamb will continue to serve the journal as consulting editor.

R. Lee Clark, Jr., director of the University of Texas M. D. Anderson Hospital for Cancer Research, has been elected to the Cancer Committee of the American College of Surgeons.

Roy P. Forster, professor of zoology at Dartmouth College, left for Europe January 27 to spend several months visiting universities and biological laboratories. The remainder of his sabbatical leave will be spent in research on the energetics of cellular transport in renal tubules at the Bermuda Biological Station for Research and at the Mount Desert Island Biological Laboratory.

Mariafranca Carpaneda, assistant professor of biology at Quincy College, Quincy, Illinois, is returning to Milan, Italy, after a year and 4 months of teaching and research in the U. S. She plans to continue research on *Chlorella* with a chemical antibiotics producer there.

E. C. Hamblen, professor of endocrinology in the Duke University School of Medicine, is on a 3-week lecture tour of western cities. In Los Angeles, he will present a course at the Obstetrical and Gynecological Postgraduate Assembly of Southern California February 14–19 and give an address at the College of Medical Evangelists. From there he will go to Oklahoma City to participate in postgraduate courses on endocrinology. The final lecture will be given in Chicago February 23, where he is scheduled to present the annual Bacon lecture in obstetrics and gynecology at the University of Illinois School of Medicine.

Florence S. Tabor, acting dean of the School of Home Economics in Pratt Institute since the resignation of **Joan M. Rock** in 1943, has been made dean, effective February 1.

Visitors to U. S.

B. R. Seth, on leave of absence as head of the Department of Mathematics of Hindu College, New Delhi, India, has joined the Iowa State College staff for the calendar year 1949. He is teaching courses in theory of elasticity and theoretical hydrodynamics, while assisting in a seminar on research in applied mathematics. Dr. Seth will participate in the 3rd Annual Symposium of Applied Mathematics at Ann Arbor, Michigan, next June.

Erik Tetens Nielsen, insect physiologist of Pilehuset Laboratory, Denmark, and research associate, University of Copenhagen, has begun a 6-month study of the ecology of Florida insects at the Archbold Biological Station, Lake Placid, Florida. Dr. Neilsen, assisted by Mrs. Neilsen, is working in this country under the auspices of Swarthmore College. His present program is concerned with the migration of butterflies.

Grants and Awards

Research Corporation has announced a new installment of grants totaling nearly $250,000. These first grants of 1949 were approved by the Board of Directors at their recent annual meeting in New York. At the same time, announcement was made of the 1949 recipients of the annual Research Corporation Scientific Awards. They are Bruno Rossi, professor of physics at the Massachusetts Institute of Technology, and Henry Eyring, dean of the University of Utah Graduate School.

Union College, Schenectady, New York, has received a gift of $150,000 from Frank Bailey, of New York City, to establish the Frank and Mary Louise Bailey professorship of physics. Vladimir Rojansky, professor of physics at Union College since 1930, has been named to the new professorship.

The Ohio State University Development Fund has received two gifts totaling $10,000: a grant of $7,500 by the Edward Orton, Jr., Ceramic Foundation to the fellowship endowment fund, and another of $2,500 by the Illuminating Engineering Society Research Fund to finance research in the School of Optometry.

The Marine Biological Laboratory at Woods Hole, Massachusetts, has been granted $150,000 by the Rockefeller Foundation to renovate Old Main. A basement, to be constructed this spring under the entire building, will contain research laboratories, dark rooms, cold rooms, and storage space. The Foundation has also donated $100,000 for the general support of the Laboratory.

Fellowships

A 6-week General Electric Science Fellowship Program has been announced by officials of Union College and Case Institute of Technology. The study program is open to 100 science teachers to be selected on a competitive basis from 19 northeastern states and the District of Columbia. Applications must be submitted before *April 1* to Elmer Hutchisson, Case Institute of Technology, Cleveland 6, Ohio.

Smith College announces the following fellowship and scholarship awards available in 1949–50 to qualified women students for graduate work in scientific fields: 2 or more teaching fellowships each in bacteriology, botany, chemistry, geology, physics, psychology, and zoology, carrying a stipend of $900 for the first year and $1,000 for the second year, with remission of tuition fees; research fellowships, carrying stipends dependent upon the contract involved, in genetics and physics; and 7 trustee fellowships (giving tuition and residence) and 4 trustee scholarships (giving tuition only) for work in any college department (several of these will be awarded to science students). Full information and application blanks (to be submitted on or before *March 1*) may be obtained from Florence E. Young, Graduate Office, Smith College, Northampton, Massachusetts.

Colleges and Universities

The California Institute of Technology has completed its underground laboratory annex, combining facilities for housing experimental animals and for research in biology and biochemistry. Work to be carried on in the new $150,000 building will include research in immunochemistry, genetics and immunology, cancer prophylaxis or therapy, pneumococcus studies, specificity of sexual fertilization, and neurophysiology.

The Department of Microbiology of **New York University College of Medicine** announces an intensive course in the theories and techniques of virus research to be given March 21–June 3. This full time course will include lectures, laboratory work, and discussion. Credit for two full courses will be given by the Graduate School of the University. Because the number of students is limited to 12, early publication is recommended. Further information may be obtained from the Department of Microbiology, 477 First Avenue, New York 16, N. Y.

Fundamental problems of growth and malignancy are the subject of a series of meetings being presented by the Department of Pathology, College of Medicine of the **University of Vermont and State Agricultural College.** Speakers at forthcoming meetings, which will be held in the Fleming Museum at 8:00 p.m., are as follows: February 16, W. U. Gardner, Department of Anatomy, Yale University School of Medicine; March 3, Leon O. Jacobson, Billings Hospital, University of Chicago College of Medicine; March 24, M. Demerec, Carnegie Institution of Washington, Department of Genetics, Cold Spring Harbor, Long Island; April 7, Harold F. Blum, National Cancer Institute and Princeton University; May 5, T. M. Sonneborn, Department of Zoology, University of Indiana; June 2, C. P. Rhoads, Memorial Hospital and Sloane-Kettering Institute for Cancer Research.

Industrial Laboratories

Elvin H. Killheffer, of the **Du Pont Company Development Department,** Wilmington, Delaware, has retired after 29 years. An authority on tariffs, Dr. Killheffer was a member of the U. S. delegation to the United Nations Conference on Trade and Employment at Havana in 1947.

The Westinghouse Electric Corporation has made 3 appointments in its new Atomic Power Division. The men are Philip N. Ross, assistant director of research; E. L. Kuno, assistant to the division manager; and L. C. Mechling, Jr., works engineer.

Meetings and Elections

The National Malaria Society held its annual meeting conjointly with the American Society of Tropical Medicine, the American Academy of Tropical Medicine, and the American Society of Parasitologists in New Orleans, December 5–9, 1948, and elected the following officers for 194[9]: president, Wendell Gingrich, Galveston, Texas; president-elect, Paul F. Russell, New York City; vice president, Ernest Carroll Faust, New Orleans; director for a 3-year term, [E.] W. Van Hovenberg, Mt. Pleasant, Texas; and editor, Frederick L. Knowles, Memphis, Tennessee. Martin D. Young, of Columbia, South Carolina, continues as secretary-treasurer. The **American Academy of Tropical Medicine** also elected its 1949 officers: president, Lowell T. Coggeshall, University of Chicago; vice president, Ernest Carroll Faust, Tulane University; secretary, Clay G. Huff, Navy Medical Research Institute, Bethesda, Maryland; treasurer, Henry E. Meleney, New York University; and councillor, Willard H. Wright, National Institutes of Health, Bethesda, Maryland. At the same meeting workers in the fields of parasitology and tropical medicine of the midwest were organized as **Midwestern Parasitologists** and elected H. J. Van Cleave, of the University of Illinois, president. Plans are under way for a meeting of the group at the University of Wisconsin in June. Information about the meeting and membership may be had by writing David D. Lincicome, Department of Microbiology, University of Wisconsin Medical School, Madison.

The recently organized American College of Veterinary Pathologists elected the following temporary officers to serve until the final adoption of its constitution and by-laws: president, William H. Feldman; vice president, Alfred G. Karlson; secretary-treasurer, T. C. Jones.

The Cooper Union Forum is conducting three series of lectures on Sundays, Tuesdays and Fridays, at 8:15 in the Great Hall, 8th Street and Astor Place, New York City. The subject of the Sunday evening series (January 23–April 10) is "Asia in Ferment." The Tuesday evening series (January 25–April 12) is concerned with "Our Search for Mental Health." The Friday series (January 28–April 8) offers "Expressions of the Contemporary Scene."

The Institute of Medicine of Chicago, at its annual meeting on

ember 7, elected the following officers for 1949: Henry T. Ricketts, chairman of the Board of Governors; William F. Petersen, vice chairman; Herman L. Kretschmer, president; Archibald L. Hoyne, vice president; George H. Coleman, secretary; and Grant H. Laing, treasurer. Warren W. Furey, Eric Oldberg, Charles B. Huestow and H. Prather Saunders were elected to the Board of Governors. An illuminated parchment scroll was presented to George H. Coleman as a tribute of appreciation for 25 years of service as secretary. Citizen fellowship was conferred on Ella M. Salvonsen, medical librarian of the John Crerar Library.

NRC News

The Pacific Science Board, with the cooperation of the Navy Department, and assisted by funds from the Office of Naval Research, the Viking Fund, Inc., and private sources, is conducting a program known as Scientific Investigations in Micronesia. The program, which is a continuation of Coordinated Investigation of Micronesian Anthropology, carried on in the Trust Territory of the Pacific Islands for the past two years, offers 10 research openings with the following probable distribution: 2 anthropologists (archeology, physical anthropology, or linguistics); 2 botanists; 1 geographer (human or economic); 1 medical researcher (hypertension or parasitology); 1 nutrition researcher; 2 zoologists (1 in entomology). The estimated time in the field for these assignments will be not less than 4 or 6 months, with individual salary supplements ranging from $100 to $400 per month, depending upon the qualifications of the applicant. In addition, there will be a reimbursement for field expenses including subsistence and native assistance up to $100 per month. Transportation outside the continental U. S. will be arranged by the Navy Department. While unattached scientists may be sent out on individual contracts, the Board favors the former arrangement of the CIMA program, under which participants were sponsored by an institution assisting them with equipment, publication of results, and supplementary funds.

Applications for the research openings should be sent to the Pacific Science Office, NRC, 2101 Constitution Avenue, Washington 25, D. C., so as to arrive before *April 1.* It is expected that assignments and field arrangements can be made effective by early June. All applications should be on a graduate or on a post-doctoral level, and should contain details of previous field experience and academic background, as well as a description of the proposed research project, including the locality considered most desirable.

The Committee for Research in Problems of Sex of the National Research Council announces that requests for grants-in-aid during the fiscal period July 1, 1949–June 30, 1950, will be received until *March 15.* Application blanks may be obtained from the Division of Medical Sciences, National Research Council, 2101 Constitution Avenue, Washington 25, D. C. Preliminary inquiries should be addressed to the chairman of the committee, George W. Corner, director of the Department of Embryology, Carnegie Institution of Washington, Wolfe and Madison Streets, Baltimore 5, Maryland.

Members of the Committee on Aviation Psychology were recent guests of the Secretary of the Navy aboard the aircraft carrier Saipan, on a cruise to Guantanamo Bay, Cuba. The group also included Navy doctors and psychologists of the Bureau of Medicine and Surgery. En route, a regular meeting of the Committee was held to discuss the Navy's current research program in aviation psychology and to review the progress made on investigations conducted for the Bureau of Medicine and Surgery by the Committee.

H. R. Crookshank, formerly in the Biochemistry Department of the Medical College of Alabama, is now assistant executive secretary of the Division of Biology and Agriculture and the American Institute of Biological Sciences of the NRC.

Deaths

Imre, F. Patai, 54, physicist and a member of the staff of Franklin Insitute's Bartol Research Foundation at Swarthmore, Pennsylvania, died January 19 in the University of Pennsylvania Hospital after a brief illness.

Stephen Capps, 67, U. S. Geological Survey geologist, died January 19 in Washington, D. C. of a heart attack.

William Clarence Ebaugh, 71, professor emeritus of chemistry at Denison University, Granville, Ohio, died in Newark, Ohio, December 28.

The American Academy of Arts and Sciences, 28 Newbury Street, Boston, is presenting an exhibit and a series of popular lectures on astronomy during February. Prepared by the staff at the Harvard College Observatory and sponsored by the Academy, the program includes daily lectures on astronomical subjects as well as exhibits of current activities at the Harvard observing stations and transparency panels on the galaxies, the Milky Way, the sun, and meteors. The exhibit is open from 9 a.m. to 5 p.m. on weekdays and 9 a.m. to 12 noon on Saturdays. The lectures are given at 3:45 during the week and at 11:00 a.m. on Saturdays. They are open to the public without charge.

UNESCO will provide a weekly radio news program on developments in the fields of education, science, and culture, to be available to U. S. radio stations beginning February 19. The scripts will be prepared by the Paris headquarters of UNESCO and transmitted to broadcasting networks throughout the world. Radio stations in the United States may request copies of the programs, which are entitled "UNESCO World Review—Weekly Radio News About Education, Science, and Culture," from the UNESCO Relations Staff, Department of State, 1778 Pennsylvania Avenue, Washington 25, D. C.

The Avawatz Mountains, 40 miles south of Death Valley, are being mapped by Richard H. Jahns, geologist, and A. E. J. Engel, mineralogist, of the California Institute of Technology. Object of the survey is to trace the Garlock Fault, (which appears from aerial photographs to lie along the east side of the range) and determine whether this area contains the key to important regional geological structures in the Southwest. The fault

has been active for millions of years. By mapping the inner recesses of the range, which has a maximum altitude of about 6,000 feet, Drs. Jahns and Engel hope to learn how far the mountains have moved and when the moving took place.

The American Psychiatric Association's newly established Inspection and Rating System for mental hospitals in the U. S. and Canada will have as director Ralph M. Chambers, until recently superintendent of Taunton State Hospital, Taunton, Massachusetts. A Central Inspection Board of 10 psychiatrists under the chairmanship of M. A. Tarumianz, superintendent of Delaware State Hospital, Farnhurst, Delaware, will serve as the governing body of the new system. Made possible by grants from the Psychiatric Foundation, the Inspection and Rating System is designed to stimulate the same kind of voluntary improvement in public and private mental hospitals that a similar procedure developed in 1918 by the American College of Surgeons achieved in general hospitals. Communications concerning the Inspection and Rating System should be directed to Ralph M. Chambers, c/o American Psychiatric Association, 1270 Avenue of the Americas, New York City.

A method of studying wind velocities in the upper atmosphere by means of visible smoke clouds has been made possible by the V-2 rocket No. 42, fired at White Sands, New Mexico, last December. The rocket reached an altitude of about 67 miles at a speed of 3,000 mph. The smoke generator was equipped with a delay mechanism timed to function 68 sec after take-off and when the rocket rose from 20 to 40 miles, it emitted a stream of smoke clearly visible for 15 minutes. The movement of the smoke in the wind was photographed by cameras on the ground, thus measuring velocity at a height from 100,000 to 200,000 feet above the earth's surface. The equipment was designed and operated by experts from the Munitions Division, Technical Command, Army Chemical Center, Maryland.

"The Behavior of Rocks and Rock Masses in Relation to Military Geology" is the subject of volume 44, number 1, of the Colorado School of Mines *Quarterly*, now available for distribution. The author is Wilmot R. McCutchen, Lt. Col., Corps of Engineers, USA. The report may be obtained from the department of publications, Colorado School of Mines, Golden, Colorado, for $1.00 postpaid in the United States.

The Foreign Service Institute of the Department of State is instructing Foreign Service Officers and other government personnel in those phases of sociological and anthropological science appropriate to the conduct of relations with peoples of other cultures. This "area and language study" is carried out by the following staff: Henry Lee Smith, Jr., director of the School of Language Training and assistant director of the Institute; George L. Trager, professor of linguistics and anthropology; John M. Echols, associate professor of linguistics; Charles A. Ferguson and Carleton T. Hodge, assistant professors of linguistics, Naomi Pekmezian, instructor in linguistics, and Edward A. Kennard, professor of anthropology and linguistics (School of Advanced Officer Training).

Recently Received—

Report of the Chief of the Soil Conservation Service, 1948, by H. H. Bennett. Publication of the U. S. Department of Agriculture. Washington 25, D. C.: Supt. of Documents, U. S. Government Printing Office, 1948. $.20.

Soviet science (from *Pravda*). (Occasional pamphlet no. 8, November, 1948, of the Society for Freedom in Science.) Copies available from the Assistant Secretary, Society for Freedom in Science, Dept. of Zoology, University Museum, Oxford, England.

The subspecies of the Massasauga, *Sistrurus catenatus*, in Missouri by Philip D. Evans and Howard K. Gloyd. (Bulletin of the Chicago Academy of Sciences, December 22, 1948.)

Ninetieth anniversary celebration of the Iowa State College, 1858–1948. Iowa State College, Ames, Iowa.

Bulletin Analytique, Vol. VII, Parts 1 and 2. Published monthly by Le Centre National de la Recherche Scientifique, Service de Documentation du C.N.R.S., 18, rue Pierre-Cur Paris (5e).

Science Review. Official monthly pu licaion of the Metropolitan Detro Science Club.

National Research News. Publish monthly by the National Resear Council of Canada.

Symposium on spectroscopic lig sources. (Special technical publi tion No. 76.) Published by t American Society for Testing M terials, 1916 Race Street, Philad phia 3.

Australian Journal of Scientific R search. Published by the Coun for Scientific and Industrial R search in collaboration with t Australian National Research Co cil. Issued in two series. Annu subscription each series. 30/, sing issues 7/6. Ed: Australian Jour of Scientific Research, c/o Coun for Scientific and Industrial R search, 314 Albert Street, East Me bourne, C.2., Victoria.

Preliminary bulletin of postgradu courses. American College of Phy icians, Inc., Spring, 1949, Exec tive Secretary, E. R. Loveland, 42 Pine Street, Philadelphia.

Dania Polyglotta. Annual report pu lished by the Institut Danois d échanges Internationaux de Public tions Scientifiques et Littérair I.D.E., Copenhagen, Denmark.

Report of the President of the Ca negie Institution of Washington f the year ending September 30, 19

Wissenschaftliche Dienst. Publish monthly by Internationale Pres Austausch Gesellschaft M.B.H Hamburg 13, Harvestehuder Weg Germany.

New Products. Booklet published The N. Y. Journal of Commerce 63 Park Row, New York City. $.

Make Plans for—

Research Conference on Coc diosis of the New York Academy Sciences, March 4–5 (originally sche uled for March 3–4), American M seum of Natural History, New Yo City.

New York Academy of Medicin Section of Microbiology, symposiu March 15–16, New York City.

American College of Physician 30th annual session, March 28–Apr 1, New York City.